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**PHYSIOGRAPHY AND GLACIAL GEOLOGY
OF GASPE PENINSULA,
QUEBEC**

BY

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Thrust fault, rivière à la Martre. (Page 4.)

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BY A. P. COLEMAN

INTRODUCTION AND REFERENCES TO PREVIOUS WORK

It is generally assumed that all eastern Canada was covered by the Labrador ice-sheet when it reached its greatest extension; but in regard to one part of the region, the Gaspé peninsula, there is little evidence to support this view. The earliest geologists to visit Gaspé seem to have overlooked glacial matters altogether in their reports. Sir Wm. Logan crossed the peninsula near its middle, from Cap-Chat to Chaleur bay, in 1844, and his assistant, Murray, visited in the following year Shickshock mountains a little farther east, but glacial features are unmentioned in their reports; and the same is true of Richardson in 1857. In "Geology of Canada, 1863", summing up previous geological work in Canada, there are numerous references to Gaspé, but not one suggestion of glacial features. Low's account of the region in the Report of Progress for 1882-4, treats of the bedrock geology and the topography, but mentions no drift deposits, though it refers to the loose blocks strewn over the tops of Shickshock mountains. Until 1863, there is no hint of ice action in Gaspé. In that year Robert Bell, who accompanied Richardson as naturalist in his journey up Magdalen river and across to Gaspé basin, gives an account of the superficial geology of Gaspé peninsula,¹ describing "unmodified drift," a "stiff and sticky sandy clay containing gravel and boulders"; which he believed to be of local origin, since he found no travelled stones in it. He considers that floating ice carried boulders and left them on the lower levels.

The most important references to glacial action in Gaspé are to be found at a much later date in Chalmers' reports on the Pleistocene of eastern Canada, published by the Survey in 1894, 1897, and 1904. He examined most of the coast-line of the peninsula, working out the marine beaches in some detail, and recording a few occurrences of striæ, boulder clay, and erratics. In the main he agrees with Bell, that except for boulders carried by floating ice and deposited at or below the level of marine submergence, the effects of ice action to be seen in Gaspé are due to local glaciers only, since the Laurentide ice-sheet did not cross the St. Lawrence east of Québec.

¹ Can. Nat. and Geol., vol. VIII, pp. 175, etc.

During an excursion along the north coast of Gaspé he found no evidence of ice action at all for 100 miles, between Fox river and Ste. Anne-des-Monts, and believed that the higher part of the peninsula was unglaciated even by local ice.

He describes the most important of the local glaciers as occupying the trough of Chaleur bay, and as 120 miles long and 30 to 40 miles broad, with a thickness of 900 or 1,000 feet in Restigouche valley.

One of the later geologists who refers to the glaciation of Gaspé is Goldthwait¹. He examined the raised beaches in various places, and apparently thinks that the Labrador ice-sheet crossed at least a part of Gaspé peninsula; he states that "the dominant movement in the region southeast and south of the Magdalens, namely, over Cape Breton and

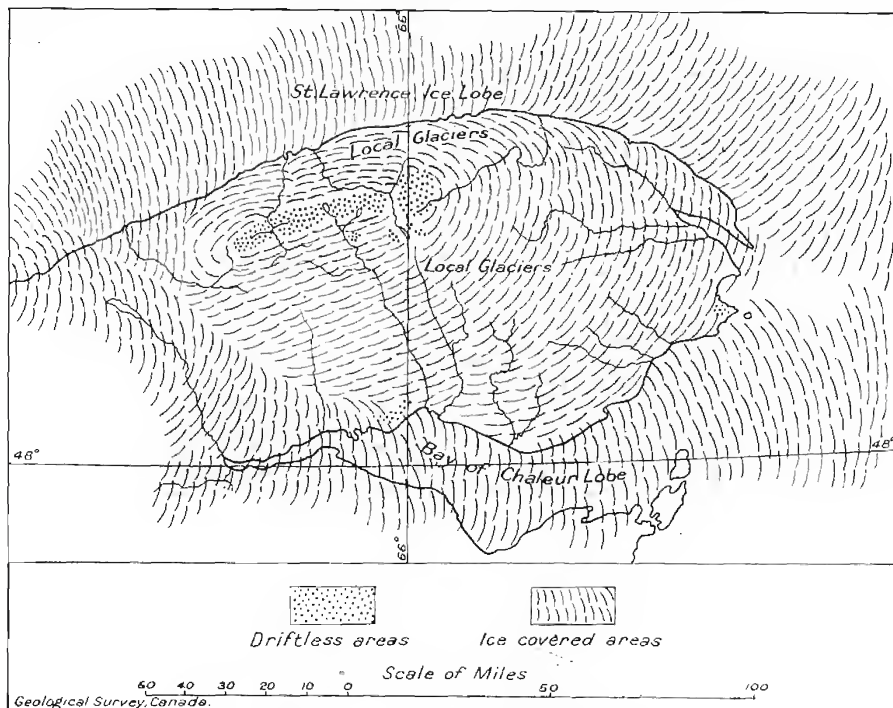


FIGURE 1. Gaspé in the Ice Age.

northern Nova Scotia, was southward, with a divergence toward the semi-circular border of the shallow basin in which the Magdalen islands occupy a nearly central position". However, in other writings he refers with approval to Chalmers' suggestions as to local glaciers, such as the Chaleur glacier, and leaves the matter open.

Hayes, in 1918, describes the Laurentide ice-sheet as moving southward over Nova Scotia to the Atlantic ocean, but thinks there may have been local glaciers radiating outward from Nova Scotia at a later time².

¹ Geol. Surv., Can., Mus. Bull. No. 14, 1915, p. 10; and Twelfth Inter. Geol. Cong., Guide Book No. 1, 1913, pt. I, p. 17.

² Geol. Surv., Can., Sum. Rept., 1918, pt. F, p. 24.

The present writer had found in 1915 and 1916 that the Labrador ice-sheet did not reach the sea in the Torngat region of Labrador, the mountainous northeastern projection of the continent at the opening of Hudson strait; but that a large area of tableland there shows no signs of glaciation, though profound U-valleys and fiords were left by large valley glaciers moving seawards. If the Labrador ice-sheet failed to cover the highest lands to the northeast of the continent it seemed probable that the highest lands toward the southeast, too, might have escaped its action (Figure 1).

There was so little positive evidence to be found in print as to the real conditions of Gaspe peninsula during Glacial times that it seemed worth while to study the Pleistocene of that region. Accordingly the summers of 1918 and 1919 were devoted to an examination of the coasts and mountains of Gaspe with this in view, resulting in a fairly complete traverse of the coast-line and visits to the highest summits of Shickshock mountains, the backbone of the peninsula. As Gaspe is 150 miles long from east to west and in places 90 miles wide, it will be understood that the work could not be done in much detail, particularly since there is no map of the mountains except the very rough one published by the Geological Survey in 1884.

Elevations were determined by the use of two aneroids checked by sea-level readings furnished by the courtesy of the Meteorological Service, Toronto. In the case of the higher elevations corrections were made for air temperatures.

MEANS OF COMMUNICATION IN GASPE

Although the first landing of white men in Canada took place on the east end of Gaspe, where Cartier planted a cross in 1534, the peninsula is still largely covered with primeval forest and is almost roadless except along its shores. The Intercolonial railway cuts across its base southeasterly from Mont-Joli near the St. Lawrence, following the Matapedia valley to the mouth of Restigouche river; the Canada and Gulf Terminal railway runs from Mont-Joli to Matane on the north shore; and the Quebec Oriental and the Atlantic, Quebec, and Western railways combined connect Matapedia with Gaspe basin, a well sheltered and commodious harbour on the eastern coast. These railways keep close to the shore and do nothing to open up the interior.

A public road runs completely around the peninsula, but the part of it between Ste. Anne-des-Monts and Fox River, on the northeast side, is so mountainous and rough as to be almost useless except for the strongest vehicles. At various places wagon roads run a few miles inland, usually following up river valleys; and one lumber road extends from Cascapedia railway station, on the south coast, up Cascapedia river for 45 miles to the Federal Zinc and Lead mine, almost in the geographical centre of the peninsula. There are no roads across the peninsula and there is no direct communication between the settlements on the north and those on the south, so that they differ from one another almost as much as if belonging to separate countries.

The lack of roads from north to south is, of course, accounted for by the chain of Shickshock mountains, which are very rugged and run from 2,000 to more than 4,000 feet in height.

The mountainous and inhospitable character of the interior of Gaspé, especially along its northern side, accounts for its backwardness in development. The fringe of settlements along the St. Lawrence depends on fishing in the summer and lumbering in the winter, though most families cultivate a few fields and do some farming. On the milder southern side farming is of much more importance and there are still some tracts of excellent land not yet taken up.

TIMBER

The larger villages of Gaspé, such as Matane and Gaspé Basin, depend chiefly on the lumber trade, spruce and balsam furnishing most of the logs, though a little pine occurs also. White birch is of importance in places as a source of spool wood; and sugar maple is found in most of the lower valleys.

The size of the timber diminishes with the altitude and above 2,500 feet it is not suitable for lumber, though available for pulpwood. Above 3,500 feet, spruce and balsam make up the forest, the trees being small and scrubby; and the exposed mountain tops are either quite bare or are covered with low bushes very difficult to force a way through.

STRUCTURAL FEATURES

That Gaspé is a part of the Appalachian system has long been recognized, and on its southern side typical Appalachian folds have been described. The northern side, though showing distinct folds in places, has been much more profoundly affected by thrust faulting. The extent of the movement of older rocks over later ones has not yet been worked out, and probably will be difficult to work out, because of the large amount of crushing and tilting of the beds that has taken place. The total compression of the region thus caused may, however, be as great as that so brilliantly demonstrated by McConnell in the eastern ranges of the Rockies, the classic example of thrust faulting in Canada.

The front of the great block of the earth's crust which was driven against the resistant Archæan continent to the north was not straight, as in the case of the Rockies, but convex, as shown by the direction of Shickshock mountains and by the strike of the rocks between the mountains and the St. Lawrence. More than eighty observations for strike and dip were made at points along the north coast, with the result of finding almost every possible orientation but with a prevalent direction north of east at the western end of the peninsula, east and west toward the centre, and south of east toward its extremity. In other words the average strike of the beds is parallel to the coast and to the mountains in the different parts of northern Gaspé.

The dips recorded average above 45 degrees towards the mountains; i.e. southeast, south, and southwest, as one goes from the west end of the peninsula to the east end; and only four dips were to the north. A considerable number were, however, noted as vertical or nearly so. Planes of thrust faulting are well displayed in several places, one of the best observed being on a shore cliff near Rivière-à-la-Martre (Plate I).

Although there is a striking arc-like arrangement of the structures of the peninsula on its northern side the geologic elements of the southwestern limb of the arc differ greatly from those of the centre or of the southeastern limb. The core of the mountains to the southwest consists of a band of schists considered to be Archæan, and the central and southeastern parts, so far as known, include nothing older than the Cambrian.

Another irregularity comes in near the centre, in the form of large, eruptive masses interrupting the east and west trending schists and sediments, the transverse band of batholithic granite called Tabletop being the most important. This mass, 14 miles long and 4 or 5 miles wide, marks the eastern end of the ancient schistose mountain core and indicates a great break in the structures where molten magma could well up.

The huge uptilted slab, or perhaps syncline, of tough schist from 2 to 8 miles across indicates a much more profound disturbance of the earth's crust along the southwest curve of the mountains than the bands of old Palæozoic sediments of the southeast; and the southward indentation of the bow shown on the geological map may indicate that the two halves were not formed by precisely the same thrust. Where the two thrusts met there was a transverse rent through which granite could ascend.

RELATED PHYSIOGRAPHIC FEATURES

When the Shickshocks were in their prime, some time toward the close of the Palæozoic, they formed a lofty chain of mountains comparable to the Rockies, and the basal structural features now evident, the core of schist and the central eruptive masses, were hidden under Silurian, Devonian, and perhaps later sediments. That the mountains were then much higher and much wider than at present seems certain from the existing river systems with their main watershed 10 miles south of the loftiest summits. The water parting probably occupied much the same position then as now, but with an elevation thousands of feet above the present watershed, since the northward slope must have been sufficient to pass over the present range when it was far higher. The absolute height one can only guess at, but the Tabletop batholith must have reached much above its present 4,350 feet and in addition must have been buried under a considerable thickness of non-conducting sediments to acquire its present granitic structure. To double its height would not seem unreasonable, so that the original range with its watershed some miles to the south may have reached 9,000 feet or more.

As weathering and the general attack upon the mountain surface progressed, the more resistant core of schist and serpentine and granite became exposed, but strong rivers, such as the Cap-Chat and the Ste. Anne, carved their way down through them as fast as the watershed to the south was lowered and so preserved their grade toward the north. Ultimately the slowly yielding schists and eruptives became the highest summits and the relatively soft shales and sandstones were carved down to the present low tableland of southern Gaspe. The wild upper valleys of Cap-Chat and Ste. Anne rivers, cut down 2,500 feet below the mountains on each side, may be accounted for in this way; but the valley of Cascapedia river, beginning in a lake 1,700 feet above the sea within a mile of the north side of the Shickshocks and flowing to Chaleur bay, demands some other explanation, probably the presence of an original depression leading southward.

Until the present work was undertaken the highest points recorded in the Shickshocks (Figure 2) were mount Logan, 3,768 feet, and mount Albert, 3,560 feet; though the recently published topographic map indicates 4,000 feet over the area called "Tabletop mountains".

Beginning at the west the watershed crossed by the Intercolonial on its way from the St. Lawrence to Chaleur bay is only 751 feet above the sea, and a wide valley separates Notre-Dame mountains on the west from the Shickshocks on the east. Thirty miles beyond the low pass on the railway, mount Bayfield rises to 3,471 feet, according to Logan, but is cut off from the next high points by the profound canyon of Cap-Chat river, scarcely 500 feet above the sea. What may be called the Logan range rises immediately beyond, culminating in mount Logan (3,768 feet) 12 miles east of Bayfield.

A few miles farther east there is a depression to 1,900 feet at the headwaters of Cascapedia river, which flows south to Chaleur bay; and then a rapid rise to 3,000 feet, ending with the small tableland of mount Albert (3,660 feet). The deeply incised valley of Ste. Anne river (620 feet) separates mount Albert from the highest and most extensive mass of all, the granitic area of Tabletop, where about 30 square miles are above 3,000 feet and six points climbed during the fieldwork here reported on rise to 4,000 feet, the highest reaching 4,350 feet.

The more resistant rocks end with Tabletop and the range loses the massive, wall-like character it has presented on its northern front for 45 miles. This wall is only about 12 miles from the sea and is strikingly visible to passengers on the steamships passing to and fro. It is surprising that the highest points in eastern Canada, seen every year by thousands of people, should never have been mapped, or named, or have had their elevation determined before this.

Beyond Tabletop the range sinks to 2,500 feet or less and spreads out more loosely, reaching the St. Lawrence and forming the shore for about 40 miles. It then recedes a few miles from the St. Lawrence, gradually becoming lower toward the southeast, and ending at last in the cliffs of the Forillon projecting like a spine into the gulf of St. Lawrence.

CHARACTER OF THE COAST-LINE

One of the most striking features of the map of Gaspé is the dramatic contrast between the north and the south coasts of the peninsula. The north side is a smoothly sweeping curve of shore without a single bay in which a ship can take shelter. The little harbours are all at the mouths of rivers and except at high tide can scarcely be entered even by coasting schooners; but the east and south sides are greatly indented and include the perfectly sheltered Gaspé basin in which large ships can anchor. This may be accounted for by supposing a depression of the southern side, allowing the sea to flood the lowlands and form estuaries at the mouths of rivers, as suggested by Chalmers. This depression to the southeast must have been mainly preglacial, since postglacial elevation is proved all round the shores of Gaspé by terraces and raised beaches, especially notable on the side toward the St. Lawrence where most of the habitable land is of this character.

Goldthwait believes that some postglacial sinking has taken place on the Chaleur Bay side, apparently after the rise recorded in the raised beaches, since the sea is now actively cutting cliffs along that shore¹.

¹ Twelfth Inter. Cong., Guide Book No. I, pt. I, p. 120.

FIGURE 2. Sketch map of the higher parts of Shickshock mountains, Matane and Gaspé counties, Quebec.

On the north side there are many bold shores with cliffs of rock rising hundreds of feet and sometimes running continuously for miles, and there are similar relations on the east, especially near rocher Percé (Plate II A); but on the south cliffs are less frequent and are low, and often the land sinks gently toward the sea as marshes, or sand stretches, or gravel bars.

The north side of Gaspé is without an island, and Bonaventure island, near Percé, is the only important one on the southern coast.

ECONOMIC GEOLOGY

SOILS

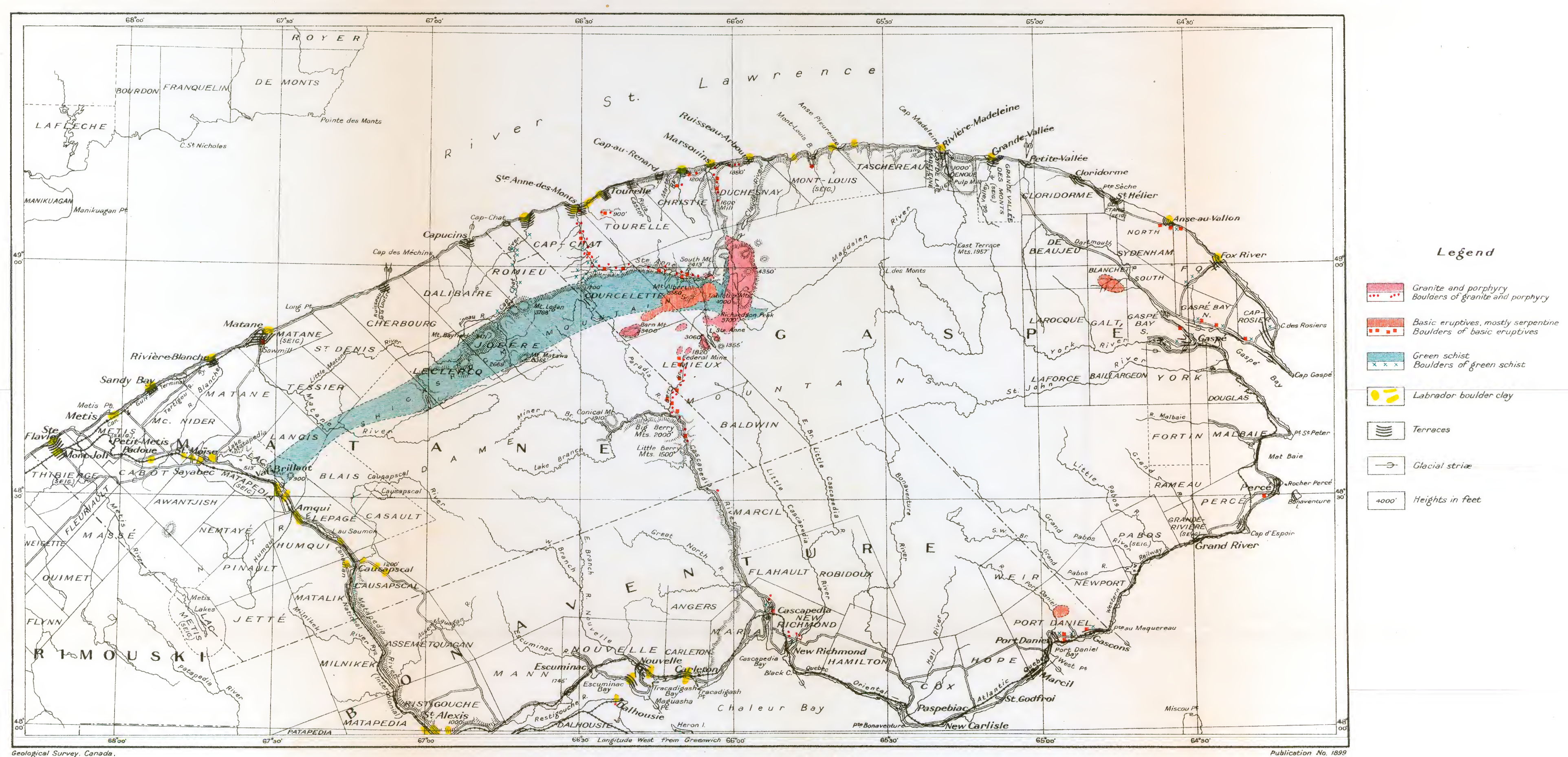
Most parts of Ontario and Quebec have soils due either directly or indirectly to the action of glaciers, many of the strongest clay soils being formed by the weathering of boulder clay. To this Gaspé is a striking exception, since the great Labrador ice-sheet never crossed it and the small glaciers radiating from the mountains deposited very little boulder clay. The chief soils are of three kinds, residual, marine terrace materials, and flood-plain deposits of rivers.

Over the greater part of Gaspé rock comes to the surface on the hills, and the soil has been formed by the weathering of bedrock in place, so that the character of the soil varies with that of the rock beneath. Where the rock is shale or slate with limestone present in ribs or as separate beds it is often excellent, particularly in the lower parts between the hills. On the crests of hills and ridges such soils are apt to be thin. The residual soils over sandstones or conglomerates are naturally poor. Residual soils are farmed successfully at a number of points on the north side of Gaspé and on the highlands along the Matapédia. The areas of slate and also of basic eruptive on the south side of Gaspé provide good soils, often cleared as farms, but the prevalent sandstones and conglomerates are less favourable for agriculture.

Marine terraces form most of the level land of northern Gaspé and nearly all the villages and the main roads are located on them, so that the earliest fields to be cultivated were naturally on such terraces. Unfortunately many of these small plains are of poor beach gravels and sands. Often, however, the terraces of the shore are continued up the river valleys, on delta deposits formed at different stages of sea-level, providing very good soils. These old marine shelves are confined to the neighbourhood of the sea and never rise more than 200 or 300 feet above present sea-level toward the west, sinking to about half that height on the east.

River flood-plains afford the richest soils of Gaspé and on the north coast they have the additional advantage of comparative shelter from the raw winds and fogs of the St. Lawrence. Surprisingly fine crops of grain and hay may be seen along such flats in the valley of Ste. Anne river, where of recent years farmers living near the coast have taken up lots of government land. Unfortunately these choice localities are comparatively rare and represent only a small part of the available farming land of the peninsula.

It is generally stated that land in the peninsula above 1,200 or 1,500 feet is subject to frost and undesirable for settlement. But lands at this elevation are actually being worked near Causapsca in the Matapédia valley, and potatoes and other garden vegetables have been successfully raised at the Federal Zinc and Lead mine, 1,800 feet above the sea. As in other parts of Canada it is to be expected that the danger of summer frosts will diminish as the land becomes more completely cleared.



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ECONOMIC MINERALS

A considerable number of economic minerals have been reported from Gaspé, including coal, petroleum, and asbestos, among non-metals; and gold, copper, zinc, lead, and chromium among metals. Until recently it cannot be said that any of the deposits have shown much promise. The Devonian-Carboniferous rocks of the south coast are of too low an horizon to provide workable coal seams; and the Palæozoic sedimentary rocks that show signs of oil and gas appear to have been too much fractured and faulted to retain important stores of these fuels.

Asbestos occurs of both the chrysotile and the hornblende varieties, but is not known to be of a grade worth working; and in most cases the finds of metallic minerals have been on too small a scale to be exploited. The development within the last few years of the Federal Zinc and Lead mine in Lemieux township near the centre of the peninsula opens up new prospects for a mining industry, however, since large amounts of high-grade ore have been disclosed in its workings. Other discoveries of zinc and lead ores have been made near by and it may be that the "Heart of Gaspé", hitherto neglected and almost inaccessible, will be opened up as a mining region¹.

The geological associations of these extensive veins of zinc and lead ore are decidedly promising, for they occur in slate accompanied by some limestone penetrated by eruptives, both acid and basic. The Tabletop batholith must have cooled slowly in contact with slates and other sedimentary rocks, which were crushed and faulted at the time of the elevation of the mountains, so that there was an opportunity for magmatic fluids to circulate through their fissures. These relations are similar to those of many western mining regions of importance, and suggest interesting possibilities in this oldest but most neglected part of Canada.

OUTLINE OF PRE-PLEISTOCENE GEOLOGY

PALÆOZOIC SEDIMENTS

In order to follow effectively the glacial geology of the region it is necessary to know something of its bedrocks, so as to trace the source of transported materials. The lower parts of the peninsula consist of the usual sedimentary rocks—sandstones, conglomerates, shales, and limestones—and include formations determined as Cambrian, Ordovician, Silurian, Devonian, and probably lowest Carboniferous.² In some cases these rocks are fossiliferous, but it has been found in practice that the lithological characters of boulders are most important for the Pleistocene geologist, since non-fossiliferous rocks furnish by far the greater number of resistant fragments to serve as records of ice motion. Among the sedimentary rocks on the north side of the peninsula only certain quartzitic sandstones and the curious boulder conglomerate called in the Geological Survey reports "limestone conglomerate," both mapped with the Cambrian, proved of importance. On the south side none of the sedimentary rocks of the Silurian or Devonian proved of much value in tracing routes of ice transport.

¹ For details see pp. 41 and 42.

² Twelfth Inter. Geol. Cong., Guide Book No. I, 1913, pp. 82, etc.

PRECAMBRIAN

The rocks of greatest interest for this purpose are the schists mapped as Precambrian, and the eruptives, both making important parts of the higher mountains and both including resistant types of rock. They should, therefore, be described more fully.

The Precambrian, as mapped near the headwaters of Ste. Anne and Cap-Chat rivers, includes hornblende and chlorite schists, frequently found as boulders or pebbles in glacial deposits, mica schist, not found far away from its source, and slate, hardly distinguishable from the Cambrian slates to the north. No gneiss or granite is known to occur in this belt of Precambrian.

The best Precambrian section, so far as the writer is aware, is on the east side of lake Matapedia, forming the southern half of its shore and occurring also on four islands.

A hill near the southeast corner of the lake consists of pale grey, rather glassy quartzite, showing no stratification, and, probably, forms the southern side of the band of Precambrian. This quartzite is more ancient looking than any of the quartzitic sandstones observed among the later rocks.

The islands at the south end of the lake consist of fine-grained, massive-looking greenstone and grey-green schist, but on the mainland to the east epidotic amygdaloids with pillow structure occur, and seem to penetrate pale grey arkose which encloses a few pebbles. These metamorphic rocks resist well and provide important data as to the ice motions, since they are on the whole easily distinguished from the later sedimentary materials.

PALÆOZOIC ERUPTIVES

Most valuable of all are the eruptives, especially those occurring in the higher parts of the Shickshocks, since they not only resist well, but are readily recognized in drift deposits. They include granites and rhyolites and also very basic rocks such as porphyrites and peridotites. The granites will be referred to first.

The highest part of the mountains, called Tabletop, is formed mainly of granite supposed to be of Post-Devonian age, since it disturbed Devonian rocks in its eruption. It is found in contact with rocks of all ages from Precambrian to Devonian and has somewhat modified them by contact metamorphism.

The main area of granite lies crosswise of the trend of the Shickshock structures, with a length from north to south, as shown on the geological map, of about 12 miles, and a width of about 4 miles. There are also isolated peaks of porphyry rising through the Devonian just to the south and west of the main area.

The granite, so far as observed, is fine to medium-grained and pale pink or reddish in colour. Gneissoid or pegmatitic varieties have not been found. It is a very distinctive rock quite unlike the coarse-textured granites, gneisses, and pegmatites common in the Laurentian north of the St. Lawrence.

The most important of the basic eruptives is peridotite, generally transformed to serpentine. The largest area is that of mount Albert, just west of the Tabletop granite mass. It is elongated from east to west and, as shown on the map, extends for 18 miles along the southern side of the main range of the Shickshocks near the headwaters of Ste. Anne and Cascapedia rivers. There are also small bosses of serpentine shown on the map on Dartmouth river, southwest of the village of Fox River; and near cap D'Espoir. Serpentine weathers rapidly and, therefore, is not as useful as granite for glacial work, but the outcrops are so located as to be of importance in determining the direction of ice motion.

Porphyrite of a basic kind (probably diabase porphyrite), sometimes associated with amygdaloidal phases, occurs as hills along the north shore of Chaleur bay, often forming the actual coast. The position of these areas makes them of little importance from the present point of view; but the amygdaloid found on the southeastern part of lake Matapedia, as mentioned above, though not shown on the map, is of considerable interest.

Having referred briefly to the distribution of rocks in place it is now possible to understand the significance of the boulders of one kind or another occurring in boulder clay or as erratics.

It may be said in concluding this part of the work that typical Laurentian, Keewatin, and Grenville rocks are nowhere found in Gaspé, so that boulders of them must have been derived from the great Archæan area north of the St. Lawrence.

GLACIAL PHENOMENA

WORK OF FLOATING ICE

Every traveller along the north shore of Gaspé is struck by the great numbers and large size of the boulders on the shore. These include many varieties of granite, gneiss, and pegmatite and also anorthosite, gabbro, green schists, and occasionally crystalline limestone. They are travelled stones derived from the north shore of the St. Lawrence, and their size, often reaching diameters of 10 feet or more, compels one to account for their presence by ice transport. There are three ways in which this may have occurred: (a) by the southward spread of the Labrador ice-sheet; (b) by the aid of icebergs when the land stood lower; (c) by floe ice enclosing boulders along shore and drifting with them across the St. Lawrence. The probability is that all three modes of transport have at some time been in operation; the last one perhaps still being to some extent effective.

The geologists who have specially referred to these boulders, Bell and Chalmers, support the iceberg theory of transport during a late Pleistocene time of depression of the land.

Blocks such as these become less frequent towards the east along the north coast of Gaspé and are rare on the south coast along Chaleur bay, as is natural if they came from north of the St. Lawrence.

Although boulders of foreign rocks are most numerous and striking along the present shore, they occur also on the marine terraces that rise inland; but above the highest ancient sea-levels they are no longer found, as noted by previous geologists and confirmed by the writer. Evidently, the ice that brought them could not lift them above sea-level, which

implies that the means of transport was floating ice and not a continental ice-sheet. Since the blocks are often huge, icebergs seem more competent for the work than floe ice.

These drift blocks from the other side of the St. Lawrence have their economic importance, being used for building stone and foundations. They are used in building the finest churches of the villages along the north shore and they supply beautiful collections of almost every kind of northern Archæan rock. The churches at Cap-Chat, Matane, and elsewhere are worthy of study on this account.

WORK OF LAND ICE

The Labrador Ice-Sheet

Both Bell and Chalmers conclude that the Labrador ice-sheet did no work in Gaspé, and state that the residual soils due to the crumbling of rock in place, especially on the north side of the peninsula, show no signs of a great ice-sheet having passed over them. Though this is true in the main, yet there seems good evidence that the Labrador sheet actually crossed the St. Lawrence valley and impinged on the north shore of Gaspé, though not rising upon the higher land, much less scaling the mountains.

At almost every river mouth along the north shore typical blue boulder clay with striated stones may be found, and usually some of the enclosed stones are granite or gneiss or some other rock that must have come from Labrador or the Quebec region. Such boulder clay has, however, not been found more than a mile or two inland and never more than about 100 feet above sea-level. The Labrador sheet reached Gaspé but was prevented from advancing inland.

Chaleur Bay Lobe

As already mentioned the Shickshock range sinks to only 751 feet above sea-level, where the Canadian National railway turns southeastwards from the St. Lawrence valley. Dr. Chalmers suggests that a local glacier moved northwards here; and as evidence he refers to "bosses glaciated on the south sides, transported blocks and drift from the interior and thick beds of undisturbed decayed rock materials on the north or leé side of the foothills," near Little Metis to the north of the watershed.

The lowness of the hills near the watershed, where they do not surpass 1,000 feet, or at most 1,500, makes the supposition of local glaciers improbable, and the evidence for a northwestward movement of ice at that point does not seem to be strong. On the other hand, several lines of proof converge to show that the main Labrador ice-sheet pushed across this low pass toward the southeast.

Morainic materials of various kinds occur at several points on the pass and down the valley on a scale that can hardly be accounted for by a small local glacier. Kame gravels make the actual summit near St. Moïse, and typical morainic hills block the valley of the Matapédia 15 miles farther southeast near Amqui, forming the dam which causes lake Matapédia. A small amount of boulder clay containing striated stones is found at various places on the hills, and typical blue till with soled boulders, etc., occurs at places in the bottom of the valley as shown in excavations for a water supply at Sayabec. These glacial deposits are too large and widespread to be the result of small local glaciers.

¹ Geol. Surv., Can., vol. XVI, 1904, p. 254 A.

Striated and moutonnées rock surfaces also are found at numerous points in the valley and on the hillsides, the striæ mainly running northwest and southeast. Positive proof as to whether the ice went up the valley or down has not been found, but near Sayabec and on islands in lake Matapedia the scouring and grooving are so pronounced that the presence of an important glacier must be assumed; and at points so near the watershed this ice mass could hardly be local, but must have been a part of the continental sheet pushing southeast from the depression of the St. Lawrence valley.

However, the strongest evidence for the movement of the Labrador ice-sheet over the low pass in the mountains is furnished by the drift boulders, such as blocks of granite and (less often) gneiss, which have been found at a number of places along the Matapedia valley and nearby hills. These occur, with a great preponderance of local rocks, in stone heaps at different points, but are best found in the river deposits, no doubt derived and concentrated from the drift. At the mouth of Matapedia river, where it joins the Restigouche, large pebbles and small boulders of granite and gneiss of Laurentian appearance are found, though only in small numbers. These must have come from the Laurentian region north of the St. Lawrence. Pebbles and boulders of amygdaloid occur also, probably from the Precambrian area northeast of lake Matapedia; and a few scattered masses of limestone conglomerate have no known source except the outcrops of this rock to the north.

It may be considered as proved that the Labrador ice-sheet extended across the St. Lawrence and down the Matapedia valley to Chaleur bay and that the glacial phenomena of the region were not due to the action of local glaciers. This does not exclude the operation of such local glaciers after the continental ice-sheet departed from the pass between the St. Lawrence and Chaleur bay.

Local Glaciers

It has been shown that the Labrador ice-sheet divided into two lobes at the western end of Gaspé peninsula, one lobe filling the St. Lawrence channel and the other following Matapedia valley and the basin of Chaleur bay. These lobes passed on each side of the peninsula but met beyond it and continued as a single sheet of ice. The space left between the two lobes was, however, not left bare, but was largely covered by local glaciers, as suggested by Bell and Chalmers. They describe one such glacier as filling the York and Dartmouth valleys at the east end of Gaspé, and this was probably the largest.

There is evidence that ice from the Shickshocks passed over mountains about 2,000 feet in height at the Federal Zinc and Lead mine, since boulder clay with enclosed boulders from the north is found there, and similar stones derived from the mountains are scattered along the whole valley of Cascapedia river. There were also local glaciers radiating northwards and northeastwards from the Shickshocks, as shown by the distribution of boulders and by the directions of striations on rock surfaces. It is very probable that the glaciers just mentioned met the two lobes of the Labrador ice-sheet and blended with them, thus reinforcing the main sheet which passed southeastward.

There is no evidence that glaciers worked on the highest parts of the Shickshock mountains, for their surfaces consist of loose blocks of the underlying rock, seldom showing any displacement; and no striated surfaces or boulder clay have been found above 2,500 feet.

There are, however, small cirques, commonly enclosing one or more lakes, at several places on the north side of the mountains at about the 2,500-foot level, showing that cliff glaciers must have been active for a long time. This work was done probably after the more general ice action mentioned above.

In general it may be said that the effects of local glaciation in Gaspé are not strongly marked and may easily be overlooked. Bell and Chalmers emphasize the frequent occurrence of residual soils where the rock has weathered in place, and most of the surface of Gaspé above the level of marine deposits is of that character. Boulder clay is rarely found, and then only in valleys, and it is mainly the scattered stones derived from the mountains that prove that ice once covered the lower ground. The residual soils and the V-shaped, zigzag river valleys are proofs that the region was in general only lightly touched by ice.

RAISED BEACHES

Marine terraces occur all around the shores of Gaspé and attracted the attention of the older geologists, especially of Bell and Chalmers, so that many details are on record regarding them. The first definite mention appears to have been by Bell in 1863, when he states that several species of marine shells are found 8 miles up Metis river at 245 feet above sea-level¹. Chalmers refers to them at many places, and more recently Goldthwait discusses them, making special mention of the Micmac beach found at 20 feet above sea-level on the north side of the peninsula². Chalmers and Goldthwait agree that the beaches rise higher from east to west and also that the north side of Gaspé has been elevated more than the south side. Fairchild, who visited the south side, arranges the isobasic lines of his map in such a way as to imply no great difference in the elevation of the two sides³. He usually makes the upper level of marine action considerably higher than it is made by former writers on the subject. His account puts the highest marine level near Gaspé basin on the east at 240 feet, and the highest toward the west end at 581 feet, near Sayabec; but the highest beach mentioned by Chalmers, at Ste. Flavie, northwest of Sayabec, reaches only 345 feet.

The writer made many aneroid readings at points all around the shores, with the result that the evidence of greater elevation toward the west was confirmed, the highest probable beach, south of Ste. Flavie, being at 434 feet. It is probable that wave action was very slight when the sea first penetrated along the shore at the close of the Ice Age, since the centre of the depression of the St. Lawrence must have been still filled with ice. Probably Fairchild's reliance on small deltas formed by streams coming into quiet water is justified as determining the initial marine stages. When the ice had disappeared from the St. Lawrence basin the splendid beaches found at lower levels would be formed.

¹ Can. Nat. and Geol., vol. VIII, 1st ser., p. 180.

² Twelfth Inter. Geol. Cong., Guide Book No. 1, pt. I, pp. 81 and 120.

³ "Post-glacial Uplift of Northwestern America," Bull. Geol. Soc. Am., vol. 29, 1918, p. 217.

The plotting to scale of the writer's results shows a steady rise of the main beach levels from east to west, but it cannot be said that any individual beach has been traced continuously for long distances, as has been done with several of the ancient lake beaches in Ontario. As might be expected the beaches on the south side of Gaspé are much less striking than those on the north side, where the stretch of water was so much wider than on Chaleur bay, and where wave action must have been so much more powerful.

DETAILED DESCRIPTION OF FIELD WORK

Beginning at the low pass followed by the Intercolonial railway between Notre Dame mountains to the west and the Shickshocks to the east, the Pleistocene features of the north shore of Gaspé will be described from point to point to cape Gaspé. The south coast will then be taken up from east to west; and next the Cascapedia valley northwestwards to the watershed. Afterwards accounts will be given of inland features on Cap-Chat river, Ste. Anne river, and Shickshock mountains; and finally the geology of Cascapedia river and the Federal Zinc and Lead Mine region will be taken up.

Attention was directed chiefly to Pleistocene features during the field work and the bedrock geology will be referred to only incidentally. The Survey reports and the work of Dr. J. M. Clarke, mentioned on a former page, may be referred to for accounts of the Palæozoic rocks and their fossils and also for descriptions of the general structural features of the region, which are complex and full of interest but require far more detailed field work than has yet been devoted to them.

STE. FLAVIE AND MONT-JOLI

Ste. Flavie is built upon the Micmac terrace, about 20 feet above mean sea-level: to the south there is a well-marked shore cliff cut in clay containing Laurentian boulders and evidently formed by the Labrador ice-sheet coming from the north or northwest. This boulder clay, blue in colour and typical, is found at road cuttings in various places toward the east in the same shore cliff, as well as along the railway just west of Mont-Joli, 263 feet above the sea.

Going inland by the road to Mont-Joli two higher terraces are passed before reaching the railway, which is a few feet below the rear of a fourth terrace, at 267 feet. Following the road to the south beyond the town, marine levels are found at 194 and 263 feet, and probably at 398 feet. Above this, large Archæan boulders occur up to 434 feet on the hills, probably ice-rafted and indicating a transient higher sea-level which has left no well-marked terrace. On a hill a mile or two southeast of Mont-Joli small boulders of granite and gneiss are found in stone heaps along with striated stones of local origin, apparently left by the Labrador sheet and not due to floating ice.

Above the level of the railway glacial materials are only thinly spread and the crumbling bedrock, mainly soft slate, forms the soil of the hills.

The relations just described—of marine terraces on which rest ice-rafted boulders, and of blue boulder clay of northern origin at lower levels, and weathered bedrock at higher ones—occur at various places to the east of Ste. Flavie, as at Metis, Sandy Bay, and Rivière-Blanche. To mention in detail the individual observations would lead to much repetition.

MATANE

At Matane, 36 miles to the east, an important river empties and its valley provides excellent sections of Pleistocene deposits and the older rocks. The Micmac beach is fragmentary here and the waves of the St. Lawrence are cutting into the next terrace in places, showing 20 feet of blue boulder clay with some Archæan stones, 18 feet of stratified marine gravel, and 2 or 3 feet of sandy soil. Going inland, terraces occur at nine levels, the highest one at 280 feet. In some places successive bars are found at higher and higher levels, as, for instance, between 98 and 118 feet. Ice-rafted blocks were observed 20 feet above the highest beach.

Marine shells, *Macoma* and *Mytilus*, were found plentifully at 100 feet; Bell has reported shells at 245 feet, 8 miles up Metis river,¹ farther to the west.

About a mile inland a cutting on a recent extension of the railway to a mill 3 or 4 miles up Matane river shows typical boulder clay, but no Archæan stones were found in it; and on the east bank of the river, at the mill, boulder clay rests on a striated surface of limestone. There is evidence in the rounding of the surface that the ice came down the valley, *i. e.* from the south and not the north. A hill reaching 280 feet on the west side of the river between the two points has the character of a kame, and specimens of coarse granite and anorthosite occur in the gravel.

The evidence at Matane points to the presence of Labrador ice coming from the northwest and ending at the kame, where it was met by a local glacier coming from Shickshock mountains to the southeast.

MATANE TO CAP-CHAT

East of Matane there is little to note until Cap-Chat is reached, but two striated surfaces observed along the way may be mentioned, one running north, the other north 10 degrees east, on a surface of slate near ruisseau à la Loutre (Plate II B), both probably caused by the northward movement of a local glacier. At Capucins, also, striæ were observed along the road running 15 degrees or 20 degrees west of north on hard sandstone.

Where Cap-Chat river enters the St. Lawrence, a little east of Cap-Chat, ten terraces were recorded, rising from 20 feet to 207 feet, the last some miles up the river. Archæan boulders were found on all of them and a few granite or gneiss boulders of Archæan appearance were seen along the river near the foot of the mountains 10 or 12 miles inland, and 395 feet above the sea. These may be accounted for as transported by floating ice driven south by northerly storms on what must have been a long bay opening into the St. Lawrence. It is, however, possible that they were borne by a local glacier from Tabletop 20 miles to the east. Blue boulder clay with Archæan stones is found at the mouth of the river.

There are striking terraces and bars with rock cliffs behind them around the hill which forms the cape; and near the lighthouse a curious stack of sandstone 20 or 30 feet high rises above the terrace and is supposed to resemble a cat sitting up, thus giving the name to the place. Marine shells occur in a gravel terrace at 77 feet above the sea.

¹ Can. Nat. and Geol., vol. VIII, 1863, p. 180.

STE. ANNE-DES-MONTS

For various reasons more time was spent at Ste. Anne-des-Monts, 8 miles east of Cap-Chat village, than at any other place, and no less than fourteen terraces were measured, running from 19 to 270 feet above the sea. Most of these occur along the valley of the river or on the hills on each side. Archæan boulders are frequent to the level of the highest beach, but above that are boulders of local sandstone or slate or else granite like that of Tabletop, or serpentine from mount Albert.

Careful examination of the beach pebbles at the mouth of the river showed that most of them had the peculiarities of the Tabletop granites 25 or 30 miles to the southeast. They may have been brought by the river, which has a fairly steep grade, 18 feet to the mile, or more probably by glaciers spreading from the highest parts of the mountains, which are of granite, and reaching the present seashore, where they occur widely along the beach. *Macomas* and other sea shells show in a gravel beach at 48 feet.

As in other localities the amount of drift above the marine terraces is small and the soils of the hills, which reach 900 feet within 3 miles of the sea, are mainly residual and due to the crumbling of slate.

A continuous succession of bars and beaches is found at Tourelle¹ (Plate III B), 5 miles east of Ste. Anne, eleven having been observed between 86 and 212 feet.

RIVIÈRE-À-LA-MARTRE

To the east of Tourelle relations are similar as far as Cap-au-Renard, where the foothills of the Shickshocks approach the present shore. At this point the road branches, one branch following the seashore at the foot of cliffs, the other, now little used, running inland and climbing the hills to 800 feet before descending to Rivière-à-la-Martre in the next valley. Along the shore road cliffs rise to 330 feet, and evidently any marine terraces that may have existed have been destroyed by wave action on the present beach. The valleys of the small rivers or creeks give the only opportunities for tracing the old water levels. Along rivière à la Martre (Marten brook) these are well developed, beginning with the Micmac beach at 19 feet and ending at about 200 feet above sea-level. A beach at 130 feet is very pronounced.

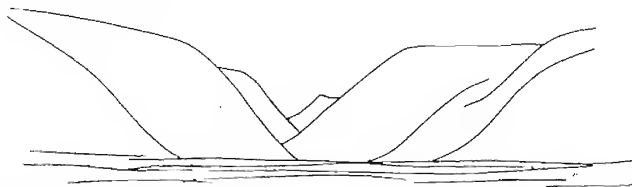


FIGURE 3. Re-entrant forms and V-shaped valleys, rivière à la Martre.

Characteristic boulder clay with Laurentian stones is exposed at the mouth of the creek, and boulders carried by floating ice are found a little above the marine terraces, but on higher ground there is very little drift, though a few granites and serpentines from the mountains to the south occur occasionally.

¹ French for turret. So called after a very slender stack of sandstone (designated by the Geological Survey "pillar" sandstone) about 25 feet high, 100 yards north of the shore at high tide.

A walk of 5 miles up the brook valley, following a lumber road, showed a fall of 355 feet, or 71 feet per mile; but the V-shaped channel is well graded. The brook is crooked and its valley displays very marked re-entrant forms (Figure 3). No important deposits of drift were seen except the terrace sands and gravels formed as deltas by the creek when the land stood at lower levels. These partly filled a preglacial valley but are now being cleared out again, so that rock in place frequently forms the creek bed.

The valley is cut 700 or 800 feet below the general level and is typically V-shaped. This and the striking re-entrants mentioned above show that it has never been shaped to any important degree by a valley glacier.

MARSOUINS

Two roads run between rivière à la Martre and Marsouins, one about 5 miles in length along the shore, the other, $1\frac{1}{2}$ miles longer, over the mountain. The shore road runs at the foot of impressive cliffs and is impassable at high tide, so that the road inland is much used in spite of very steep grades.

Going east by it, farms are met to a height of 760 feet, the soil being mainly residual but of good quality. Some fields are being cleared at higher levels, also, and it may be that the smaller amount of fog at the higher levels atones for the greater exposure to the cold, northerly winds.

It was noticed that the fog often extends only a little way inland, so that instead of the stunted spruces and birches of the shore there are well grown trees up the valley, including cedars $3\frac{1}{2}$ feet in diameter at the butt, sugar maples $1\frac{1}{2}$ feet thick, and yellow birch of good size, as well as stumps of large spruce and white birch.

After the steep climb out of the valley to about 1,000 feet there are $2\frac{1}{2}$ miles of tableland, the highest level reaching 1,200 feet, before the road begins to descend below 1,000 again. The tableland is inclined, rising from the cliffs along shore with a gentle slope towards the Shickshocks to the south; and the only evidence that it was ever ice-covered is the presence of some boulders of Tabletop granite scattered over it. These must have been brought by a local glacier from the mountains 12 miles to the south.

Rivière aux Marsouins is larger and longer than rivière à la Martre and forks 2 or 3 miles from its mouth, but its valley is of the same type, deeply cut and V-shaped with bedrock showing at the bottom in many places. The eastern branch of the river was followed up for 8 miles on a road leading to a small sawmill. The rise in that distance is 1,107 feet, the gradient increasing in proportion to the distance from the shore.

The usual blue Labradorean boulder clay is found near the mouth of the river, followed by well-formed marine terraces in the valley up to a height of 203 feet, the best being at 126 feet. Very few Laurentian boulders were seen; but many large and small boulders of the Tabletop granite occur in the river valley as far up as it was traversed.

MARSOUINS TO RIVIÈRE-MADELEINE

Farther east the road climbs rapidly to about 1,000 feet and remains above this level for $3\frac{1}{2}$ miles, the highest point reached on the tableland being 1,350 feet. It then descends quickly to sea-level at Ruisseau-Arbour where the regular boulder clay and terraces are found, the highest certain one being at 153 feet, though ice-raftered boulders continue to 238 feet.

Beyond this the tableland recedes somewhat and the road crosses some hills, but runs for the most part on low terraces or the beach as far as Mont-Louis (Plate IV), where two comparatively low headlands with rocky cliffs shelter a shallow bay 2 miles wide. A bar corresponding to the Micmac beach at 20 feet cuts off a swampy valley and the lower terraces beyond are occupied by farms for 2 or 3 miles from the sea. This valley is wider, and the hills enclosing it lower, than in the region just described toward the west.

The next point of interest to the east is at anse Pleureuse, where a gravel bar at 31 feet dams a beautiful lake about $2\frac{1}{2}$ miles long, said by the fishermen to be 45 fathoms deep. It is walled on each side by steep slopes or in places cliffs, rising to 800 or 1,000 feet. This is one of the very few lakes found along the north coast of Gaspe and is clearly a preglacial river valley dammed by a sea-beach at a late stage in the postglacial rise of the land. It is not a fiord cut off by a bar, since the steep shores present well-marked spurs which a glacier would have truncated.

This old valley, extending at least 240 feet below sea-level, gives evidence that the land stood much higher above the sea in preglacial times than now.

Similar deeply cut valleys, but without lakes, separated by hills sometimes reaching 800 feet, are passed at St. Antoine and Manche d'Épée on the road to the mouth of Magdalen river, the longest stream entering the St. Lawrence from the north side of Gaspe. It has its headwaters in Tabletop, the highest part of Shickshock mountains, and follows a devious course of more than 70 miles, first northeastwards, then eastwards, and finally northwards to the sea. Its channel is very much less perfectly graded than that of Ste. Anne river or Cap-Chat river and its valley is far more crooked, having extreme re-entrants, as if entrenched meanders belonging to a time of much less slope when the land stood lower (Figure 4).

Seven miles from the sea there is a striking canyon enclosing a fall of 62 feet with strong rapids above and below; but near the mouth of the river the slope is gentle and the current slow.

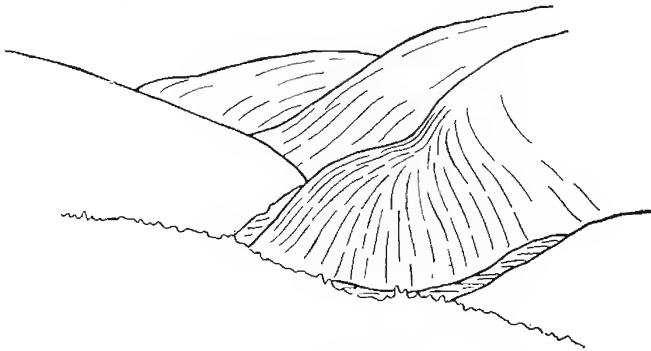


FIGURE 4. Entrenched meander, Magdalen river.

A sawmill and pulp mill have been erected at the falls, the head of which is about 300 feet above the sea, and a dam raises the water 23 feet above this to regulate the power. A railway built from the village of Rivière-Madeleine to the mill rises to 897 feet above the sea. The country to the east reaches at least 1,000 feet, and the broad-topped hills on the

west side of the valley are probably as high, so that the relief of the region is pronounced.

A little boulder clay along the railway near the sea, and also near the falls on the river, is the only evidence of ice action. The bedrock displayed in the railway cuttings is greatly tilted and crumpled slate, often breaking into slender, square pencils; and it quickly weathers down into soil.

Terraces were found at seven levels, the highest 130 feet above the sea.

Although the railway from the pier at Rivière-Madeleine to the pulp mill climbs to nearly 900 feet on the mountain, a longer line surveyed to Grande-Vallée, the next village to the east, does not rise above 375 feet.

FROM RIVIÈRE-MADELEINE EASTWARDS

The road east from Magdalen river ascends the mountain rapidly and in about 3 miles reaches an elevation of 800 feet. The mountain rises to the south probably to 1,000 feet, and may be considered the last outlier of the Shickshocks along the shore of the St. Lawrence. The whole width of mountainous shore is about 45 miles.

Eight miles east of Rivière-Madeleine is the village of Grande-Vallée where, as the name suggests, there is a considerable area of farming land, most of it on marine terraces. Many shells occur in a road cutting about 75 feet above the sea.

At Petite-Vallée, 4 miles east, striæ are found on sandstone beds in slate, the direction being from 5 degrees to 20 degrees east of north and indicating ice moving outward from the mountains. The settlement is almost continuous from Grande-Vallée to Chloridorme and pointe Sèche, a distance of 18 miles, the fields extending widely over the usual terraces which rise in places to 125 feet.

St. Hélier (Grand-Étang), the next settlement, important for its cod fishery, is, however, enclosed between rocky hills forming striking cliffs on the shore. The small lake (Étang) is about $1\frac{1}{2}$ miles long and is said by a man in charge of a fish hatchery to be from 13 to 18 fathoms deep. As its outlet is not more than 7 or 8 feet above high tide it goes far below sea-level, though it is not so remarkable in this respect as the lake at anse Pleureuse. The hills rise with steep slopes from the lake, and the road eastward runs 2 or 3 miles inland over hills reaching 650 feet above the sea. For about 12 miles there is an interruption of the settlements by this mass of hills which forms almost vertical cliffs facing the sea.

From Anse-au-Vallon, the first settlement east of St. Hélier, the country is hilly but with cultivated terraced valleys to Fox River, a village of some size, chiefly dependent on the cod fishery. The village is mainly situated on a terrace only 13 feet above mean sea-level, but spreads to higher terraces at 20 and 36 feet. There is a well-marked terrace at 58 feet also, and there are possible water-levels at 121 and 148 feet.

Between Anse-au-Vallon and Fox River a little boulder clay with well striated stones was seen at about 100 feet above the sea, but most of the surface consists of rock weathered in place, as at other points along the north shore of Gaspé. Some blocks of serpentine mixed with local boulders of sandstone no doubt came from a small hill of serpentine to the southwest on Dartmouth river, as indicated on the geological map. A few boulders of weathered basic eruptive and of green schist seem to have come from the interior, but their source is unknown.

In general very little evidence of ice action was found along this northeastward fronting coast of Gaspé, except a few Laurentian boulders at low levels, evidently ice-rafted from the Labrador side of the gulf of St. Lawrence.

FOX RIVER TO CAPE GASPE

There are two roads to cape Gaspé from Fox River, one southwest over the hills, the other southeast along the shore. Going southwestward along the valley of the river, about $1\frac{1}{2}$ miles from the sea, striæ running in a northeast direction are found on hard layers in slate, and at about 2 miles boulder clay occurs, but so far as seen without foreign boulders. The lowest terrace extends to this point, and beyond it the plain rises gently for 2 miles to an escarpment of sandstone with some slate, capped by limestone (Plate V B), probably of Devonian age.

The elevations along the road to the southwest run from 445 feet to 724 feet and represent the main ridge of the Shickshocks, here trending southeast. Boulders and pebbles of schist conglomerate and of green schist occur on the highland. They have the appearance of Precambrian rocks and no known source can be assigned to them except that they must come from the interior.

Following the shore road southeast of Fox River there are wide marine terraces occupied by farms as far as cap des Rosiers where the plain has a width of 3 or 4 miles with terraces at 45, 56, and 103 feet, reaching the foot of the escarpment. Ascending the steep front of the escarpment there are two other probable sea-levels at 139 and 157 feet. Large ice-rafted Laurentian boulders are scattered over the lower terraces.

The road south crosses a depression in the ridge at levels from 350 to 370 feet, and on the way up, at about 320 feet, boulder clay was found containing blocks of sandstone and limestone as well as fragments of hornblende schist.

Southeast of the road the escarpment continues for 4 miles as a series of bold and sometimes overhanging cliffs ending in cape Gaspé. The peninsula is very narrow and rugged and rises in places 500 feet or more above the sea. The lighthouse at the end is 280 feet above the sea and the cliffs to the north are probably 100 feet higher.

The limestone forming the cliffs dips steeply to the southwest. Sandstone boulders scattered over it were evidently brought by ice from the Devonian sandstones a few miles to the northwest.

The solid geology of the Forillon, as this narrow ridge is called, has been worked out and excellently described by Clarke.¹

GENERAL FEATURES OF THE NORTH COAST

It was thought by Bell and Chalmers that land ice had done no work in this region, Bell stating that for 100 miles on the north shore of Gaspé the surface consists of decomposed rock and is unglaciated²; and Chalmers claims that from Fox River to Ste. Anne-des-Monts there is no evidence of glaciation except boulders brought by floating ice.³

¹ Twelfth Inter. Geol. Cong., Guide Book No. I, pt. I, p. 104.

² Can. Nat., vol. VIII, first series, p. 262.

³ Geol. Surv., Can., vol. XVI, 1904, pp. 253-4.

From the foregoing account it will be seen that these views must be modified, since boulders derived from the mountains are found widely scattered even to the seashore, showing that there was a movement of local glaciers outward from the Shickshocks toward the coast. The small amount of glacial material and the extensive surfaces of weathered rock show, however, that their action was not long continued nor powerful. The belief that the Labrador ice-sheet did not reach the shore of Gaspé is disproved also, for characteristic boulder clay with Archæan stones is found at low levels near the mouth of almost every river valley.

One of the most striking features of the coast is the splendid series of marine terraces, higher toward the west than toward the east, which provide sites for villages and roads as well as most of the farmland of the region, the sea having prepared the way for human occupation.

EAST AND SOUTH SIDES

Beyond the long and rocky promontory of the Forillon is Gaspé bay, the deepest indentation on the whole coast of the peninsula, and all the geological and most of the human features are changed. The southern side of Gaspé consists mainly of Devonian sandstones and conglomerates of a prevalent red colour instead of the grey or purple Cambrian and Ordovician slates which make up most of the north coast. Bays and harbours are numerous, rivers are much longer and usually have a gentler flow than those of the north. Wide and fertile plains are frequent, occupied by farmers by profession, so that fishing and lumbering are minor industries. Many of the inhabitants are English speaking and there are Scotch and Irish communities also, in contrast to the north side where only French is spoken.

On the east and southeast the shore faces the open gulf, and outside of the bays is exposed to violent wave action. The western part of the shore, on Chaleur bay, is less and less wave beaten until the mouth of Restigouche river is reached, where wave action is unimportant. Marine terraces are much less prominent than on the north side and boulders of granite or gneiss are seldom noticed.

The mountain range to the north gives shelter, and the adjoining waters, as the name Chaleur bay suggests, are much warmer than those of the St. Lawrence, so that the climate is milder.

GASPE BAY AND BASIN

Twelve miles northwest of its mouth Gaspé bay is cut nearly in two by accumulations of beach materials reaching out from each side, and just beyond this Gaspé basin turns off to the west with a length of 4 miles, followed by marshy islands at the outlet of York river. At the head of Gaspé bay, also, there are low islands forming the delta of Dartmouth river.

Boulder clay occurs scantily along the northeast shore of the bay, the stones contained in it being mostly local, though fragments of hornblende schist and of an agglomerate formed of some basic eruptive must have come from the interior.

There are well-marked striæ on sandstone near Grande Grève and at other places, the direction being parallel to the axis of the bay.

On the southwest side of the bay, and on the shore of Gaspé basin also, boulder clay is rather common, enclosing only local stones except for some hornblende schists. Striae were found on sandstone on the promontory between the two bays, running southwest, as if the local glacier coming down the Dartmouth valley had spread westwards.

The hill behind the village of Gaspé rises to 477 feet and shows no evidence of ice action, the boulders upon it seeming entirely local. Its summit may have risen above the glacier, which does not seem to have been very thick.

Terraces, usually indistinct, occur at 45, 70, and 180 feet. One or two small fragments of granite or gneiss were found, perhaps rafted round from the Labrador coast when the sea stood higher. Both Chalmers and Fairchild report a marine level at 235 or 240 feet, but this was not observed by the writer, perhaps because not sufficiently looked for.

The glaciers coming down the Dartmouth and York valleys and combining in the basin of Gaspé bay, as suggested by Chalmers, must have been among the most important of the local glaciers or ice-sheets radiating from the mountains, and their effects are more readily recognized than those of the northern glaciers mentioned before.

ROCHER PERCÉ

No work was done between Gaspé Basin and Corner of the Beach, 20 miles to the south. The "beach" (Grande Grève) is an old gravel bar rising 10 feet above high tide and running 4 miles south from Barachois (said to be an Indian term for a gravel bar). It suggests bars like that on which Fox River is built on the northwest side of Gaspé, but is distinctly lower than the Micmac beach of Goldthwait, which seems confined to the north coast.

From Corner of the Beach a road follows the shore southeastward to Percé, rising on terraces up to 225 or 230 feet, and then passing over hills. Blocks of granite and gneiss were seen above this, and a gneiss boulder 3 feet long was observed at 262 feet above the sea, indicating that floating ice must have reached this level, which is about 20 feet above the highest marine terrace indicated by Chalmers and Fairchild¹.

Except a little boulder clay on the road southwest of Percé no evidence of glacial action was seen, and the mountain, having an elevation of 1,230 feet as shown on the map, must have risen above the ice.

On Bonaventure island, 2 miles to the southeast, a surface of conglomerate shows striae running north 60 degrees east, perhaps caused by the northward sweep of the Chaleur lobe of the great ice-sheet.

Terraces are indistinct on the island, probably because the lower parts on which they would be impressed were sheltered from wave action by the high ground facing the sea; but ice-borne boulders were found at several places, the highest being a block of gneiss at 295 feet, which is well above the old marine level as determined by Fairchild. It may have been left by the Chaleur ice lobe just referred to.

The Percé region, projecting into the stormy gulf of St. Lawrence, shows the effects of modern wave work in magnificent cliffs, and the extraordinary stack, Percé rock (rocher Percé) (Plate II A), from which the name of the village is derived. This narrow island, 288 feet high and

¹ "Post-glacial Uplift of Northeastern America", p. 217.

pierced by a wave-formed tunnel, has vertical or even overhanging walls and is the most striking bit of scenery on the coast. Its special features and the geology of the region around have been carefully studied and admirably described by Clarke¹.

PORT DANIEL

Southwest from Percé the country is mostly flat with marine plains and terraces, but near Gascons there are hills presenting more variety. Terraces were found at 95 and 150 feet, and boulder clay occurs as the road ascends from the creek. The hills, which reach about 300 feet along the road to Port Daniel, were crossed by ice from the interior, which left morainic material including many boulders of Archæan-looking schists of various kinds, especially hornblendic. Similar schists occur in place on mount Albert in the Shickshocks, 80 miles to the northwest. Serpentine blocks may have come from the same region and coarse granites may have been brought from Tabletop. A little boulder clay rests on steeply tilted grey-brown limestone and contains well striated stones.

Similar erratics are found near Port Daniel and in hills beyond on the way to Marcil, and striæ having the direction southeast are reported by Chalmers².

Serpentine is reported 4 or 5 miles north of Port Daniel and that asbestos was mined there for a few years. It is possible, therefore, that some of the drift boulders mentioned may have a nearby source instead of coming from the distant mountains.

Boulders of a coarse conglomerate like that of the Cobalt series, and quartzites of two kinds, should be mentioned as occurring with the rocks just referred to as probably coming from the Shickshocks. It is evident that our knowledge of the older rocks of the interior is quite imperfect, and it may be that features of both geologic and economic interest remain to be discovered.

Southwest of Marcil there are low plains and a terrace at 77 feet, as one approaches St. Godfroi. A few boulders of green schist and of quartzite show that ice from the interior passed over it.

NEW RICHMOND

The next point examined was New Richmond on Little Cascapedia river, where the country is once more hilly.

A shore cliff shows blue till with well striated boulders of limestone and schist, and a road crossing the river running east gives outcrops of similar till with some granites and porphyrites as well as the rocks mentioned. Stone heaps on the hills at 360 to 380 feet show similar boulders along with local sandstones and conglomerates; and it is evident that the region has been glaciated by ice from the north.

Terraces are found at 37, 50, and 185 feet. As might be expected no more Laurentian-looking boulders are seen on the terraces after passing from shores facing the gulf of St. Lawrence to those of Chaleur bay.³

¹ Twelfth Inter. Geol. Cong., Guide Book No. I, pt. I, p. 95, etc.

² Geol. Surv., Can., vol. II, 1886, p. 14 M.

³ Goldthwait has found shells here 40 feet above the sea but no beaches above 75 feet. Twelfth Inter. Geol. Cong., Guide Book No. I, pt. I, p. 120.

Very similar conditions exist at Cascapedia station, near the mouth of the river of the same name, though no boulder clay was seen. A mile west of the river there is a railway gravel pit in river deposits belonging to a terrace formed at sea-level.

CARLETON AND NOUVELLE

A range of low mountains runs northeast and southwest along the west side of Cascapedia bay at a distance of 2 or 3 miles from the shore, and then bends westwards at Carleton, where some work was done. A good path leads up Carleton mountain, whose height is given as 1,830 feet, the lower part being of slate and the highest point consisting of weathered diabase or porphyrite. A certain amount of drift was seen up to about 1,200 feet, where boulders of a basic eruptive occur resting on the slate. Whether these are ice transported is uncertain, since they may have come from the highest summit, perhaps a mile to the east, though there is a slight depression between. If they were ice-borne this is the highest point at which glacial work has been found on the southern side of Gaspé. No granites, serpentines, or hornblende schists, such as might have come from the Shickshocks, were seen; and probably these mountains were never crossed by a glacier moving southwards.

Terraces occur at 48, 77, and about 175 feet near Carleton; and a mile west of the village a fine kame of gravel and boulders overlies a boulder conglomerate on the railway, which is close to the seashore. This massive kame was, probably, built by the Chaleur ice lobe at some stage in its recession.

A few miles west, near Nouvelle, there is another striking kame along the road just north of the railway and on a terrace are boulders of amygdaloid, porphyrite, and green schist as well as of red sandstone and conglomerate, probably brought from the west by the Chaleur ice lobe.

On the road south over the hills to the Dalhousie ferry is widespread boulder clay with striated stones, all apparently local, and similar boulder clay occurs on the New Brunswick side of the bay.

The only notable point on the road westwards towards Matapedia was the finding, near Escuminac, of a large boulder of limestone conglomerate, very like rocks in place near Metis on the north coast of Gaspé; and near Gross point opposite Campbellton of a block of crystalline limestone suggesting the Grenville limestones.

MATAPEDIA VALLEY

The valley of Matapedia river is fairly well graded, having a fall of 520 feet between Matapedia lake, which may be considered its headwaters, and its junction with Restigouche river, near sea-level, a distance of 53 miles, about 10 feet per mile. Its lower end has been cut down canyon-like through a tableland having an average elevation of about 1,000 feet. It provides the lowest pass between Notre-Dame and Shickshock mountains and is considered the western boundary of Gaspé peninsula.

That it was once occupied by a lobe of the Labrador ice-sheet is proved by the presence along the river near its junction with the Restigouche of boulders and pebbles of granite and gneiss of Laurentian appearance, of limestone conglomerate, and of a fine-grained quartz conglomerate not known to occur this side of Sayabec near the St. Lawrence watershed.

A steep, winding road leads from the left bank of the river to the top of the tableland, which rises from 880 feet, at the edge, to 1,000 feet a mile or two inland. Beyond this to the northeast the country is rolling. A similar tableland rises across the narrow valley to the west. A number of farms have been taken up on this plateau and the steeply tilted crumbling slate with some limestone beds furnishes a good soil. A few boulders scattered over the fields or collected beside the roads are chiefly of limestone or of harder parts of the slate, often well striated, but there is occasionally a quartzite brought probably from the northeast. Though no Laurentian stones were found, it is evident that an ice-sheet more than 1,000 feet thick must have moved down the valley.

The Restigouche valley (Plate III A), running westwards from the junction, is cut down in a similar way through the tableland; but the only foreign stones found along the river were of quartz porphyry and of porphyrite, Laurentian boulders apparently being absent. The ice coming from this direction had a much longer route to traverse after leaving the Laurentian region so that Laurentian boulders should be rarer than in the Matapedia valley.

CAUSAPSCAL TO AMQUI

The next region studied begins at Causapscal, 35 miles up the river, and 454 feet above the sea. Boulder clay occurs on the hills on either side of the river; and on the southwest side, at 950 feet, small boulders of granite and amygdaloid were found on stone fences. On the northeast side granites, gneisses, porphyrites, and quartzites occur along with more numerous local sandstones and limestones. The tableland (Plate VII A) reaches 1,223 feet 4 or $4\frac{1}{2}$ miles east of the river, and the presence of boulder clay with striated stones and the types of boulders just mentioned makes it clear that ice from the St. Lawrence region covered the district to a greater height than that.

In the valley, in addition to boulder clay, striations were found running 40 degrees to 70 degrees east of north, a somewhat surprising direction.

Following up the valley boulder clay was found near lac au Saumon, but no moraine was observed as a dam to form the lake. Two miles beyond the lake gneiss boulders were seen, and at Amqui the valley has a pronounced morainic character with knobs and kettles. An esker or kame is used as a gravel pit at the southeast end of the village.

An excursion to a hill of quartzite 5 miles north showed along the way surfaces of boulder clay, containing mainly local stones. The quartzite hill is 900 feet high and has ice-rounded surfaces with faint striæ running from north 20 degrees east to southeast. The quartzite shows no bedding but has a large scale conchoidal fracture and is extremely hard, in spite of which it has been quarried lately for the building of a church at Amqui.

It is worthy of note that the lower part of the walls of the church is built of typical Laurentian boulders brought by rail from St. Anaclet on the Intercolonial railway 13 miles west of Mont-Joli and 58 miles from Amqui. Fragments of these rocks will, therefore, be common around the village in the future; and Laurentian boulders will probably occur along the railway to the northwest, accidentally rolled from the flat cars used in their transport.

VAL-BRILLANT AND SAYABEC

The morainic country continues northwest of Amqui, forming the dam at the outlet of lake Matapedia; and the fields on the hills to the south are very stony, but most of the boulders are local.

The north side of the lake is hilly and wooded and not taken up as farms. The islands at the east end of the lake, and also the north shore at that end, consist of Archæan rocks, as mapped by the Geological Survey, and have been referred to earlier. The islands have fine moutonnées surfaces with striæ running south 50 degrees or 55 degrees east corresponding to the direction of that part of the lake and of the valley in general.

A fertile plain extends from Val-Brillant to Sayabec, according to Fairchild the highest marine level, 581 feet above the sea. The village is just beyond the upper end of lake Matapedia. Excavations in the streets for water mains showed 6 or 8 feet of blue boulder clay including many solid boulders of limestone, often finely striated; and their source was evident, since bluish-grey limestone underlies the clay. Some quartzites occur, also, but no granites or gneisses were seen.

Hills to the northwest, rising to 770 feet, show a veneer of till, much more weathered than that in the village, and charged with more quartzites than limestones, as shown in stone fences. The only boulders probably brought from the west were limestone conglomerates; but, on the other hand, none of the amygdaloids or schists of the Precambrian 8 or 10 miles to the east on Matapedia lake were observed. If the ice had come up the valley they could hardly have been absent.

On bare hillsides at intervals for a mile there are strongly marked striæ on slate, running south 70 degrees or 80 degrees east, i.e., in the direction of the valley.

Striæ having about the same direction are found on slate 3 miles west of Sayabec along the railway, and blue boulder clay of the usual kind is found in all the lower parts. A kame-like gravel hill is touched by the railway between St. Moïse and Padoue stations farther west, carrying the evidence for powerful glacial action beyond the watershed, which is at 751 feet, $2\frac{1}{2}$ miles east of St. Moïse.

It can hardly be doubted that a lobe of the Labrador ice-sheet crossed this pass and continued down the valley, having its surface hundreds of feet above the level at which boulder clay and Laurentian stones were found near Causapscal, that is, above 1,223 feet.

THE SHICKSHOCKS ON CAP-CHAT RIVER

Turning to inland exploration, the first part of the Shickshock mountains to be described will be that 12 miles southeast of Capucins on the north coast. This can be reached most conveniently from Cap-Chat village, from which boats are poled up Cap-Chat river for about 33 miles to its forks in the mountains. This route was taken in the latter part of July, 1918, but owing to bad weather and the lack of knowledge of the mountains by the writer's guides, less was accomplished than was hoped for.

It was intended to climb mount Logan, shown on the geological map as having a height of 3,768 feet, and about 17 miles up the river. The guides had not heard of the mountain and maintained that mount Nicolabert, farther up the river, was the highest peak, so it was agreed the expedition should go to that point.

Logan himself climbed the mountain which has since received his name, and he determined its altitude in 1844. Three or four other peaks are mentioned by him and their heights given, but the positions of these mountains on the map do not correspond well with Logan's description, so that they are difficult to identify¹.

Logan gives only a brief outline of his journey and makes no reference to Pleistocene geology in the route through the mountains.

The marine terraces near the mouth of Cap-Chat river have already been referred to, and the first $23\frac{1}{2}$ miles, to the junction of Pineau river from the west, is outside the mountains. A few granite and gneiss boulders are found up to this point, which is about 343 feet above the sea by aneroid. A lumber road 20 miles long is said to reach Pineau river from Cap-Chat.

Beyond this the river runs between the mountains for $9\frac{1}{2}$ miles to the Forks, whose elevation is 434 feet. Just beyond, to the south, there are falls past which according to the guides boats do not go.

Logan gives the elevation where he left the river for his overland journey to the Cascapedia as 587 feet, but he had passed two falls before this, one of 10 and the other of 60 feet, and had gone completely through the mountains, so that he must have been some miles above the forks where the writer's party halted.

THE BROTHER OF NICOLABERT

From the forks an ascent was made of the nearest mountain, a mile northeast, called by my guides Le Frère de Nicolabert (Plate V A). It consists of a narrow ridge rising steeply to 2,546 feet, as determined by aneroid and corrected for temperature. It is about in the position of mount Matawa as shown on the geological map, the elevation of which is given as 3,365 feet, altogether too great a discrepancy. A careful reading of Logan's somewhat vague report on his work in the region shows that mount Matawa should be farther north, in line with mount Logan, and that a peak called by him South mountain, 2,413 feet, is in the position of The Brother of Nicolabert. The difference between Logan's 2,413 feet and the writer's 2,546 feet is probably accounted for by a failure to correct the reading for temperature in the earlier work. Neither Logan's name nor the clumsy one used by the Cap-Chat guides seems very suitable.

From the summit it was evident that mount Nicolabert, across the river valley to the west, though much higher than "The Brother" which we had climbed, was surpassed by at least three other mountains, one a dome continuous with Nicolabert to the west, Logan's mount Bayfield (3,471 feet), and two other dome-shaped mountains toward the north. One of the last two must be mount Logan.

"The Brother" is built of nearly vertical hornblende schist and has cliffs toward the northwest. It is wooded to the top and presents none of the features of a glaciated summit. A swampy lake half-way to the river shows no evidence of a morainic dam; but boulder clay appears near the river at the forks, indicating the former presence of a valley glacier. The boulders along the river included no granites or gneisses and seemed to be of local origin.

¹ Mount Bayfield (3,471 feet) shown on the topographic map in the west corner of Joffre township was triangulated from the north shore of the St. Lawrence by Prof. L. B. Stewart of the University of Toronto and shown to be really 4 miles a little west of south in the township of Leclercq.

A splendid canyon more than 2,500 feet in depth occurs between Nicolabert and a mountain ridge to the northeast, apparently a continuation of the Logan range. This part of the Cap-Chat valley presents probably the finest scenery in the Shickshocks.

Where cliffs are not too steep the whole region is wooded, except the tops of the highest mountains, the timber being mainly coniferous, spruce and balsam, with a few scattered white pines; but birch and maple, the maple sometimes more than a foot in diameter, are found also in the valleys.

LOGAN RANGE

The party passed out of the mountains and landed at Pineau river, just beyond them, proposing to reach mount Logan by walking across country to its foot. The region is densely wooded and the course of about 3 miles southeast was very crooked. A camp was formed at 1,450 feet, still in thick woods, where the slope became very steep.

From this camp two excursions were made up a slope of 45 degrees or more to the crest of a ridge at about 2,500 feet. A half mile southwest of the point of ascent a peak rises to 3,086 feet, overlooking Cap-Chat valley with mount Nicolabert in a southwest direction on the other side and mount Bayfield farther in the same direction. Turning northeast the ridge rises to about 2,800 feet in a quarter of a mile, dips a little, and in half a mile reaches about the same elevation again. Another dip follows when the ridge turns southeast and culminates, after $1\frac{1}{4}$ miles, at 3,285 feet, the highest point reached in this excursion.

Thus far the mountains traversed had the character of a ridge with very steep slopes, sometimes cliffs, toward the west and north, and gentler slopes south and southeast, the whole forming a broad horseshoe 2 miles from southwest to northeast with a valley between the end ridges.

Beyond the highest part of the ridge toward the northeast a sharp depression occupied by two ponds, each perhaps a quarter of a mile long, has the appearance of cirque basins, and drains southwards.

On the other side of this steep-walled valley rises a dome, considerably higher than the ridge to the northeast and bare at the summit. This the writer took to be mount Logan, but on a more careful reading of Logan's account, now thinks is mount Matawa, to which he gives the elevation 3,363 feet. Locally, this dome is called Couvert de Chaudron. Foggy and rainy weather and lack of supplies prevented any further exploration of this very interesting and almost unexplored range.

The rocks observed are slate at lower levels and green epidotic, chloritic, or hornblendic schists on the ridge itself, all in a nearly vertical attitude. Asbestos, of the hornblende variety, was found during our ascent of the ridge, but it is probably not of economic importance.

The sharp mountain ridge showed no signs of ice work, but the two ponds in the valley to the east probably indicate the action of small glaciers. The roots of upturned trees expose a stony clay, perhaps till, though no striated stones were found.

HEAD OF CASCAPEDIA RIVER

The next part of the mountains to be referred to is about 13 miles northeast of the junction of Pineau and Cap-Chat rivers, where a low pass leads from a tributary of Ste. Anne river to a lake draining into Paradis river, a tributary of Cascapedia river, which reaches Chaleur bay, after a course of 70 miles.

A lumber road follows up the west side of Ste. Anne river from the village of Ste. Anne-des-Monts to Côté creek, a distance of about 13 miles from the sea. Here there is a small camp, used by lumbermen and hunters, near the foot of the mountains which rise as a sombre evergreen-covered slope to a long, flat summit level not far from 3,000 feet in height. At about 5 miles southwest, following a path near the foot of the range, a hunters' camp is reached and a half mile beyond the ascent begins, the foot of the steep climb being about 900 feet above the sea.

Here the route turns southeast following up a small cascading stream for about $1\frac{1}{2}$ miles to a sharp divide 1,915 feet above the sea. A gentle descent of a mile, largely through muskegs, terminates at Cascapedia lake at a height of 1,700 feet. This is a beautiful body of water, about 2 miles long, running southeast between low mountains.

The dip in the Shickshocks at the pass is very pronounced, the ridge rising some hundreds of feet on each side, probably to 2,500 feet. The rocks observed above the plain are chloritic and sericitic schists of green and grey colours, standing nearly vertically. Although no evidence of glacial work was seen on the ridge there is boulder clay on the lower ground charged with local stones.

The pass to the headwaters of Cascapedia river is the lowest route across the mountains known to the guide, Joseph Tanguay of St. Anne-des-Monts, though there is another pass from the lake used in winter by hunters from Cap-Chat, which may be as low. This dip in the range cuts off the group of high summits of the Mount Logan region from the still higher ones at the headwaters of Ste. Anne river, and the precipitous face of the mountains here makes a marked bend to the east.

HEADWATERS OF STE. ANNE RIVER

Ste. Anne river may be navigated in canoes or boats for 33 miles, to its forks near the foot of the higher mountains, and with the exception of one or two bad chutes the whole distance is made by poling at usual stages of the water. Two expeditions were made to the mountains by this route, one in July, 1918, with J. Fortin and H. Pelletier, as guides; the other in July, 1919, with Joseph Tanguay and Wilfrid Perrée. The journey may be made in a day and a half under favourable conditions, but in 1919, with extremely low water, it required two and a half very long days. In most respects the river is like Cap-Chat river but somewhat rougher and more winding. Navigation ceases at a camp near the foot of mount Albert at 612 feet, instead of at 434 feet as on the Cap-Chat, and on the Cap-Chat the forks at which one stops are south of the highest range of mountains. Murray, who visited the forks in 1845, made the level 620 feet.

For the first 13 miles, to Côté creek referred to previously, the direction is a little east of south. It then turns east near the foot of the range, with foothills sometimes 1,000 feet high to the north; and finally at the

Grand Volume, the highest salmon fishing club house, it turns a little south of east.

At about half-way up Laurentian boulders are no longer found. After that granites from Tabletop, serpentines from mount Albert, and schists from the Shickshocks are mixed with local boulders. At various places on lumber roads along the river boulder clay is found, evidently formed by ice coming from the mountains.

The camp is not quite at the head of navigation, since a boat can be poled up to the forks half a mile above. Beyond this the river turns more to the south and there are violent rapids and one fall of 60 feet in the deep valley near mount Albert. The main river can be followed through the woods with very rough travelling for 12 miles more to the head of lake Ste. Anne on the other side of the higher mountains, giving a total length of about 45 miles.

MOUNT ALBERT

The name mount Albert was given to this mountain because Murray in 1854 ascended it on August 26, the birthday of Prince Albert. It is the most frequently climbed among the higher summits of the Shickshocks, as it provides one of the best hunting grounds for the caribou, and there is a moderately good path to the summit from the usual camp ground a little below the forks. It is well known to the French Canadian guides, who generally pronounce the name as one word, M'Albert.

The mountain is only briefly mentioned by Murray, but is described more in detail by Low,¹ who mentions its flat-topped character and the loose, brownish blocks of serpentine that form most of its surface, also the finding of a poor grade of asbestos in the serpentine. Nearer the river he found fairly fresh olivine rock, thin sections of which were described by Adams. Neither writer refers at all to glacial matters. More recently the mountain has been briefly described by Prof. Mailhot whose statement that certain portions of the summit "present a true glacial surface" does not agree with the writer's observation.²

It was ascended twice by the writer, the first route being up Ste. Anne river to Devil creek which was followed past heavy falls to Devil lake. It was thought this might be glacial. On the way boulders of serpentine and of mica and hornblende schist were seen. The lake, which is 1,522 feet above the sea, is in a wide, open valley with flat surroundings including many boulders of serpentine and hornblende schist, but is not at all cirque-like and presents no evidence of ice action.

The mountain is really a steeply walled tableland covered with weathered masses of serpentine except for a ridge of garnetiferous hornblende schist which rises a little higher than the rest and has rolled fragments down on the serpentine. It resembles some tablelands in the Torngat mountains of Labrador and seems never to have been crossed by ice, though ice may have moved outwards from it. It is like them in another respect, also, since there are polygonal solifluxion structures, with larger fragments toward the rim and smaller ones inside.

¹ Geol. Surv., Can., 1882-4, p. 7 F, etc.

² "Mining Operations in the Province of Quebec," 1918, pp. 146-151.

The second ascent, a year later than the first, was by the usual path, very steep toward the summit and including, on July 11, a small field of snow on the north side.

The average of the writer's determinations of the elevation on the two ascents is 3,660 feet, but Murray makes it 3,778, and the geological map 3,560.

On the path from the top toward the camp and at other points in the valleys leading away from mount Albert there are granite boulders and also boulder clay at levels up to about 1,500 feet, proving the motion of valley glaciers carrying fragments of Tabletop granite from the mountains on the other side of the valley.

ROUTE TO TABLETOP

From the Forks a little above the camp a poorly cut out trail leads up the northeast branch of Ste. Anne river for 2 or 3 miles and then turns south to lac aux Américains, 2,300 feet above the sea. This lake is in a profound valley with cliffs as walls and is dammed by large blocks of a moraine, so that it is clearly of glacier formation, though the valley is longer than most cirques. From the lake a very precipitous trail difficult for loaded men leads up a rocky ridge, in some places covered embarrassingly with scrub spruce, to the projecting peak which forms the eastern side of the valley just mentioned.

This mountain, which has no name, but is referred to in the writer's notes as First mountain, is 3,900 feet high, so that it excels mount Albert. The steep face of the mountain toward the plain is formed of grey-green schist, but the southeastern part is of granite, and as in the case of mount Albert, the highest point is of schist, which seems to resist weathering better than granite or serpentine.

The route goes over the bare top of the mountain, and follows the edge of the next valley toward the east through a grove of stunted spruces to a spot about $1\frac{1}{2}$ miles from the summit, low enough and sufficiently sheltered to form a camping ground. A number of aneroid readings corrected for temperature make the elevation 3,472 feet. This camp ground is fairly convenient and as comfortable as could be expected at the elevation, but the packing in of supplies from the Forks, a distance of 10 miles, including a climb of nearly 3,300 feet, is a serious drawback.

The name Tabletop (Plate VI A) is not very suitable, since the surface is rarely flat but consists of valleys and rolling hills often 500 feet or more above the general level. Mount Albert with its few square miles of flat tableland might much more appropriately have received the name.

The mountain was reached by Richardson from Magdalen river, but he gives very little information in regard to it, and, as he had no barometer, could only make guesses as to elevations.¹ The name is mentioned by Ells, who refers to "the transverse range of Tabletop mountain, with peaks but little short of 4,000 feet";² and in 1883 Low spent some time on the mountain and correctly describes its uneven surface with many lakes. He says that "the central area is about 3,000 feet above sea-level, but several peaks are higher than mount Albert. Richardson peak (3,700 feet) is the highest."³

¹ Geol. Surv., Can., 1857-8, p. 37.

² Geol. Surv., Can., 1882-4, p. 10 E.

³ Ibid., p. 9 F.

The flora of the region was studied about thirteen years ago by several American botanists who spent some time on Tabletop. There seems to be no full account of their work, but M. L. Fernald, in an article on "Soil preferences of certain alpine and sub-alpine plants," mentions that mount Albert is 3,300 feet in height, and Tabletop 3,500 to 4,000.¹ Their visit has left one name commonly known in the region—though not on the maps—lac aux Américains.

The Geological Survey map is very vague as to the details of Tabletop, but gives the name Richardson peak, 3,700 feet, with little to show exactly where it is intended to be. Low did a good deal of triangulation to fix the position of summits but his results were not incorporated in the map. The Bonaventure topographic sheet, recently issued at Ottawa, gives the name Tabletop mountains, 4,000 feet, and a little farther south places Richardson peak, 3,700 feet.

It is rather surprising that the highest group of mountains in eastern Canada should have been so neglected. There is no map which gives anything of real use for the traveller who visits Tabletop mountain.

Two visits were made to Tabletop (*montagne à Table* of some of the guides), one of six days in 1918 and another of fourteen days in 1919. About half of the time was lost in each case by dense fogs and rain; judging from the writer's experience fine weather is the exception rather than the rule, but Fortin, an intelligent man, says that occasionally there are weeks of fine summer weather.

GENERAL FEATURES OF TABLETOP

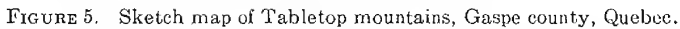
The group of mountains on Tabletop (Figure 5) differs from the other parts of the Shickshock range in being the result of a batholithic injection of granite, probably introduced toward the close of the orogenic movements forming the Appalachian chain, since Devonian sedimentary rocks have been disturbed by it. The adjoining rocks were transformed partly into schists, and near the edges of the group these schists are of importance, though the highest summits and all the interior consist of granite. The area mapped as granite is, however, considerably more extensive than the mountain group.

As shown on the geological map, which is reasonably correct, the batholith is arranged transversely to the range and the arrangement of the summits roughly corresponds to this direction, the higher points being included in an area 8 or 9 miles long by 5 miles wide. All of this area is above 3,000 feet and the greater part above 3,500. Nine points rise distinctly above 3,500 feet, six of them a little above 4,000. The highest are domes of granite.

The whole surface studied shows evidence of decay in place, all the higher parts being strewn with loose granite blocks with rounded edges and corners due to weathering. Frequently large blocks are still in place, but separated by decay along joint planes. The lower ground, where not hidden by lakes or swamps, is covered with granite debris, coarse or fine, often in the form of a gritty sand with unrounded particles. Solifluxion, shown in polygons separated by narrow depressions, is sometimes found as in Arctic regions.

¹ Rhodora, vol. IX, Sept., 1907 (new ser., No. XXXV) p. 174.

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Both moose and caribou inhabit Tabletop, also bears and beaver, but no red deer or wolves. Rabbits, foxes, squirrels, and chipmunks were not seen and no partridges, nor owls, nor hawks, and no frogs were observed, though toads are common. All the insect pests except sandflies (*brûlots*) are prevalent when the weather is warm enough. The only trees are spruce and balsam, though there are a few alder bushes. The writer's men were quite at a loss for the birch bark so essential for the rural French Canadian.

Except in two ravines cutting the tableland the timber is seldom 30 feet in height, though there are trunks more than a foot through and with 200 or 300 annual rings. Most of the older trunks seem to be hollow.

The region is a little world to itself differing in many ways from the surrounding country and particularly in the alpine type of plants at and above timber-line. These remind one of northern Labrador or the Rockies above 7,000 or 8,000 feet, and include the moss campion (*Silene acaule*), bear berry (*Arctostaphylos*), the crowberry (*Empetrum nigrum*), creeping blueberries, etc., as well as reindeer moss in appropriate places.

INDIVIDUAL MOUNTAINS

Tabletop as a whole includes probably 25 or 30 square miles above 3,000 feet, arranged as a shallow trough running about north and south, the higher points rising mostly on the east and west sides of the mass, without making definite ranges, however. The peaks on the west side, trending a little west of south and east of north, will be referred to first. They have some peculiarities in common, the western side, and usually the highest point, is of schist, and the eastern of granite; and the slope is very steep, often precipitous, toward the west and gentler toward the east. Six summits can be distinguished. So far as one can judge from the vague mountain forms on the geological map the one at the south end of the row corresponds to Richardson peak, 3,700 feet. A through valley running northwest and southeast with a depression to 3,350 feet separates this mountain from the rest of Tabletop, from which it has the look of a dome with gentle slopes.

An ascent proves that it is elongated from northwest to southeast, with a very steep slope southwest, toward the Ste. Anne valley. The slope from the eastern valley consists of granite, to within 350 feet of the top, when quartzite is found, followed by greenish-grey schist forming a narrow ridge at the summit. Aneroid readings corrected for temperature make the height 4,090 feet, much above the 3,700 feet of the Geological Survey Map No. 175, but the weather was squally and the result may be too high.

To the north beyond the "through" valley one looks down upon a broad, wooded dome reaching 3,650 feet where crossed. On its northeastern side there are two fairly large lakes enclosed by cliffs, the western one within a few hundred yards of the precipitous wall of the valley of lac aux Américains 2,000 feet below, yet they drain southeastward toward a branch of Magdalen river. Northeast of these lakes there are half a dozen ponds and a lake nearly a mile long just below the contour of 3,500, all belonging to the Magdalen system and containing trout.

Northeast of the ravine just mentioned is the "First mountain" of the writer's notebook (3,900 feet), very precipitous on three sides but descending with a gentle slope for $1\frac{1}{2}$ miles eastwards to the high level

camp. The summit is of green and grey schist, but, only 80 feet below, granite forms an eruptive contact with it, carrying off large fragments of schist. The narrow valley northeast of First mountain contains two rock-rimmed ponds at 3,340 feet and is a characteristic "hanging valley", sending a stream over cataracts for 1,000 feet to other ponds in the valley below. This chain of small lakes begins in two small bodies of water half a mile east of camp and above 3,500 feet, and includes six lakelets before the stream flowing from them is lost in forest beyond the foot of the mountains on its way to the East fork of Ste. Anne river.

After this valley the mountain front is fairly straight for $2\frac{1}{2}$ miles, rising in a mile to about 4,000 feet, the summit consisting of schist, then dipping a little, with a main summit at 4,060 feet.

A cirque-like basin without a lake separates it from the Northwest peak, the last in the row, about 3,900 feet high; but the two mountains are connected by a narrow ridge of granite between the cirque valley on the west and a deep ravine occupied by a branch of Ste. Anne river to the east.

Northwest peak is somewhat isolated and differs from the rest in sending a long ridge off to the west with steep slopes toward the lower wooded country on each side. This ridge formed the writer's route in the first ascent of Tabletop. The gently rolling top of Northwest mountain is formed of schist, followed by slate which continues in the ridge running to the west.

To the north and northeast can be seen much lower but still mountainous country cut up by valleys containing lakes, and reaching the shore of the St. Lawrence between rivière à la Martre and Grande-Vallée, as described before. The lower mountains are all wooded to the summit, but some of them probably reach 2,500 feet.

EASTERN SUMMITS OF TABLETOP

The deep ravine carved by a branch of the Ste. Anne, which flows northwards in a succession of falls and rapids, separates the last mountain of the western rim from a tableland, wooded or covered with lakes and swamps which interfere with travel. At about $3\frac{1}{2}$ miles west there is a bare dome rising above the woods, called in the writer's notes the Northeast dome. The ascent from the west is at easy angles, but stunted spruce thickets are troublesome, and the bare, gently rounded top is elongated toward the east, with a steeper descent toward the lower wooded country. The summit reaches 4,290 feet by aneroid with temperature corrections, and the limit of 4,000 feet encloses a tract reaching half a mile to the east of the highest point. The rock observed was porphyritic granite, partly very fine-grained, and sometimes enclosing masses of a more basic eruptive.

There are a number of lakes to the east and southeast and two of the largest, half-way toward camp, were named for the writer's guides in 1919, Tanguay and Perrée, lake Perrée being the more easterly. They drain toward the Ste. Anne, but the streams were not mapped.

Two miles south of Northeast dome is another dome, slightly higher but of the same kind. The upper part of the ascent showed downward moving streams of small, angular stones with grassy or mossy bands between. The top was covered with loose blocks of granite and reached 4,350 feet, and an oval area a mile in length from east to west is above 4,000 feet.

On the south side of the dome, where spruce bushes make their appearance a few hundred feet below the summit, there were patches of snow on July 21, one of which was 300 feet long by 100 broad. No snow was seen on the north side, so that probably the snow sweeps across the dome and lodges on the southeast side forming great drifts, some of which, probably, remain until fresh snow falls in the autumn.

A mile to the west, with a slight dip between, there is another elongated dome of the same kind, with an elevation of 4,210 feet.

The cairns on the tops of these two domes were made, no doubt, by the botanists camped on the shore of lake Côté a mile to the south. There are two fine lakes here, the larger, called lake Côté from the head guide of the botanists, the smaller one west of it, named Fortin for their interpreter who was the writer's head guide in 1918. The elevation of Côté lake is 3,400 feet and that of Fortin lake 3,390; they have their outlet toward a branch of Magdalen river, here flowing south. The two domes of the botanists form part of the main watershed of Tabletop.

The southernmost summit (Plate VI B), about 3 miles from the last mountain described, is a rather steep-walled ridge rising above a wooded tableland and bearing two small peaks about a third of a mile apart, one to the east, the other to the west, built of great, loose blocks of granite, separated probably by weathering along the joints. These sharp points are unique and striking because all the other summits are more or less domes and several have very gentle slopes.

Beyond the sharp descent the tree-covered tableland extends for a mile or two eastwards and southwards toward lower ground, and toward the west it runs nearly level to the edge of the ravine cut by the Magdalen. Northeast there are two lakes of a cirque-like character, one flowing into lake Côté, the other on the east side of a narrow ridge and much lower down, resembling basins on the west side of the group of Tabletop mountains.

The region shows no proof of ice action except the small cirque basins eaten into the massif from the outer slopes, and these were formed by local cliff glaciers probably at a late stage of the Ice Age; but one other feature appeared at first to suggest an ice cap over the highest part of the mass. Boulders of granite occur on several of the western summits resting on schist, which rises above the nearest granite, but the reverse is not found. This might be interpreted to mean the movement of an ice cap outwards from the higher granite domes toward the marginal mountains whose summits are of schist.

It seems more probable, however, that the granite once stood above the schist and has been lowered by differential weathering, since granite is much more rapidly attacked than schist. The small boulders of granite now resting on schist represent, it may be supposed, the cores of large blocks that rolled down when granite stood at a higher level.

The block-covered summits of the hills and mountains of Tabletop and the entire absence of boulder clay, moraines, or smoothed and striated surfaces argue strongly against an outward movement of ice from the centre; and these features, along with the sharp-edged, northwestward-facing cliffs at the edge of the table, provide conclusive evidence against the supposition that the Labrador ice-sheet ever crossed the Shickshocks.

On the gentler slopes, at 1,500 feet and lower, boulder clay containing striated stones from the mountains shows that ice moved outwards toward the sea, as indicated at numerous points inland and along the coast.

ROCKS OF TABLETOP

The Tabletop batholith consists in the main of medium-grained, reddish granite made up of orthoclase, plagioclase, quartz, and brown or green biotite, often accompanied by hornblende, and a small amount of magnetite. It seems to pass into a finer-grained, paler granite in places, and to be cut by the latter as dykes in other places. This rock, which shows a tendency to porphyritic structure—enclosing fairly large crystals of strikingly zonal plagioclase—and contains very little of the dark minerals, probably suggested the term "trachytic granite" to the earlier geologists. A fine-grained, flesh-coloured rock collected as granite on Northeast dome turns out to be really diorite, since most of its feldspar is plagioclase with a low extinction angle. There is little quartz, and the plentiful dark ingredient is hornblende with a brown and green pleochroism.

In many places patches or fairly well-defined blocks of dark grey or green rock occur in the granite, and on the north shore of Côté lake there are apparent transitions between granite and greenstone. The specimens collected are unfortunately badly weathered. A medium variety, looking in the hand specimen like syenite, is really a quartz diorite, having as dark minerals both biotite and hornblende, and a few large crystals of titanite. Darker coloured specimens, too much weathered for satisfactory microscopic study, show a tendency to ophitic structure, and one collected because it seemed filled with small cavities, suggesting a vesicular lava, proves in fresher parts to contain little masses of pyrite.

How these more basic rocks are really related to the prevalent granite where the transitions occur is not very certain, though there are places where they are enclosed as sharp-edged xenoliths, and, therefore, must be older.

In addition to the rocks just described, which were collected in place, there are many boulders at the Forks of Ste. Anne river, of which specimens were taken, some of typical granite like those referred to, but others of different kinds, particularly quartz porphyries and porphyrites. The quartz porphyries are often of the same colour as the granites, and the matrix is microgranitic, enclosing phenocrysts of orthoclase, or more often an acid plagioclase, with fewer phenocrysts of quartz.

The porphyrites examined are weathered diabase porphyrites with large and well-formed plagioclase crystals. A medium-grained diorite was collected also, composed chiefly of oligoclase, hornblende, and brown biotite, with magnetite and apatite needles as accessory minerals.

The rocks just mentioned probably belong to the Tabletop eruptives, though their definite source is unknown. Unless the basic rocks mentioned above were earlier products of the original magma and not merely fragments of older rock caught up in the irruption of the granite the amount of differentiation in this mass was slight. Nothing in the nature of pegmatite as a final stage in differentiation has been observed.

As might be expected a mass of slowly cooling granitic magma of such magnitude has had considerable effect in the metamorphosing of the adjoining sedimentary rocks, illustrated in the formation of schists and of quartzite along the western side of the mountain group.

Certain highly metamorphosed schists found in boulders at the Forks may, however, belong really to the belt of Precambrian indicated on the geological map. They include finely fibrous green schist consisting of

slender prisms of hornblende, having a blue-green and pale brown pleochroism, and a smaller amount of quartz; and also coarse dark green hornblende rocks with little schistosity, containing red garnets. Under the microscope they are found to consist mainly of hornblende with blue-green, yellow-green, and pale brown pleochroism; but around the garnets there are also pale bluish-green augites and in places a halo of intimately mixed minerals including augite and a greyish, transparent substance not determined.

Among other boulders at the Forks there are dunites and peridotites, showing in thin sections a beginning of serpentinization, which must have come from the serpentine area crossed by the river, and correspond to the fresher rocks described by Adams from mount Albert. The garnetiferous hornblende rocks mentioned are very like schists from the highest point of the same mountain.

CASCAPEDIA VALLEY

In order to see something of the southern interior of Gaspé and to visit the only mine known to be of importance a visit was paid to the Federal Zinc and Lead mine, owned by Lyall and Beidelman, of Montreal. It is almost in the geographic centre of the peninsula, and is reached by a lumber road from Cascapedia station, near the south coast. Thirty-five miles of the road are in the valley of Cascapedia river, whence a branch road made by the mining company follows a tributary, Berry brook, for about 9 miles northeast to the mine. The road, though rough for wagons, affords a good section of the sedimentary rocks from the coast inland, which have been briefly described before by the Geological Survey¹ and will not be referred to here.

Pleistocene features of interest begin near Cascapedia station, where the pebbles and boulders on the bed of the river are found to consist only of stones from the interior, such as hornblende schist, fine-grained granite, quartz porphyry, porphyrite, and amygdaloid; but foreign rocks, such as gneisses, are wanting.

Boulder clay was seen at several points and about half-way to the mine boulders of granite like that of Tabletop were found, and near the mouth of Berry brook these were accompanied by blocks of serpentine or peridotite, evidently from the Shickshocks.

The river has a well-graded channel rising in 36 miles from sea-level to about 400 feet, an average of 11 feet per mile, and scows carrying several tons of supplies for the lumbermen operating on the headwaters are hauled up to this point by teams walking on the beach or in the shallow water.

The river valley is in some places wide, with considerable areas of good alluvial land covered with fine hardwood, but in other places is narrow and V-shaped. Re-entrant forms are often striking, and for most of the distance the valley is entrenched several hundred or a thousand feet beneath the level of an uneven tableland. A topographical map, Bonaventure sheet, Series No. 36, published by the Department of the Interior, gives the plateau called Big Berry mountain an elevation of 2,000 feet, and Little Berry mountain, 5 miles to the south, is credited with 1,500 feet, these figures being taken from Ells' report, previously mentioned.

Beyond Berry Mountain camp the lumber road continues to the forks about 3 miles up, and one of the branches of the river, the Salmon branch,

¹ Geol. Surv., Can., Logan in 1844, and Ells, 1882-4, pp. 26 and 27 E.

can be followed for 30 miles farther in a direction a little west of north to a lake, 1,700 feet above the sea, described in an earlier part of this report.

The road to the mine turns northeast along Berry brook, following its northerly fork, at first through low ground until the blazed boundary line between Matane and Gaspé counties is reached, then rising rapidly to the mine, which is in the recently instituted township of Lemieux, 10 miles from the river. Aneroid determinations by the writer place the mining camp at 1,820 feet instead of 2,000, as it has been estimated previously.

GEOLOGY OF THE FEDERAL ZINC AND LEAD MINE REGION

Through the courtesy of the Federal Zinc and Lead Mine Company several days, passed at their comfortable camp, gave an opportunity to study the geology, both Palæozoic and Pleistocene, and to see the ore deposits. The solid geology has been described in a general way by Prof. Mailhiot¹ and in most respects his account is confirmed by the writer's own work.

So much of the region is heavily forested or covered by swamps that geological work is by no means easy, since rock is to be found only along the stream channels or on bare parts of the higher summits. Good exposures occur, of course, along the newly constructed road to the mine and in the strippings and excavations of the mine itself.

The rocks found along the earlier half of the road to the mine are red or grey sandstones sometimes covered with boulder clay; along the latter half, shale with some sandstone alternating with basic eruptives, partly amygdaloidal. On a road-cutting just below the camp soft shale or slate with some cherty limestone has a strike of northwest and southeast, instead of east and west as expected, and a dip of 50 degrees to 70 degrees southwest. At one place a badly weathered diabase cuts the sedimentary rocks.

A rapid ascent of 300 feet from the valley leads to the buildings of the camp, where the bush has been cleared, exposing a weathered surface of rock, slate, and chert with some shaly grey sandstone; and a boss of greatly weathered granite porphyry occurs at the summit. Strippings a half mile north at the second shaft disclose mainly black slate.

In limestone layers east of the camp Mailhiot has found fossils determined as Devonian by Kindle², so that the age of the sedimentary rocks is settled.

An excursion to Brandy brook showed slaty sandstone and a very coarse syenitic rock; the bed of the brook contained boulders of felsite, porphyry, porphyrite, and amygdaloid. As the eruptives of the region have been described by Mailhiot no particular account of thin sections made from the hand specimens collected need be given. Almost all of those studied by the writer are badly weathered.

In most places the rock surface is much shattered and decayed, looking as if it were unglaciated, so that it was a surprise to find in small amounts on both roads near the camp undoubted boulder clay with well striated stones, including serpentine, which must have come from the Mount Albert region 10 miles to the north. The mountains rising to 2,000 feet immediately north of the camp must have been crossed by a glacier coming south from the Shickshocks, though they were so lightly touched by the ice that the products of rock decay forming their surface were hardly disturbed.

¹ "Mining Operations in the Province of Quebec," 1918, pp. 117-145, and 1919, pp. 134-146, maps.

² "Mining Operations in the Province of Quebec", 1919, pp. 138-9.

FEDERAL ZINC AND LEAD MINE ORE DEPOSITS

Lead and zinc ores were found ten years ago on the site of the Federal Zinc and Lead mine (Plate VII B), which has since been developed by the sinking of a shaft to 142 feet, and by drifts aggregating 1,400 feet, as well as by stripping at several points. The veins commonly run in a direction a little east of north, i. e. across the strike of the country rock, and one has been followed more or less continuously for half a mile from the main shaft, and a second shaft has been sunk upon it toward the north end to a depth of 64 feet. On the surface the rock is greatly decayed, as suggested before, but the quartz of the vein resists better and is disclosed by stripping. In these outcrops it has, however, been much leached of its ores, particularly of zinc blende. The veins average 4 or 5 feet in width, but in places the adjoining slate has been shattered and re-cemented to a breccia several feet wide, which may be expected to provide a lower grade ore capable of concentration.

The ore below the weathered surface consists mainly of sphalerite, with a smaller amount of galena, and with quartz, often amethystine, and dolomite as gangue minerals. The minerals are sometimes well banded but more often irregularly arranged. The sphalerite is unusually pure zinc sulphide, having a honey yellow or reddish brown colour, and containing according to assays less than a half per cent of iron. The ore is stated, as a result of a number of assays of samples taken by Walter Harvey Weed, to average 7.9 per cent of zinc and 3.8 per cent of lead, and to be almost without silver.

In character the ore is much like that of Joplin, Mo., though its geological relationships are very different. In the Joplin region the zinc ores occur in flat sheet-like deposits at no great depth in Carboniferous limestone, which is very little disturbed and nowhere penetrated by eruptive rocks; but the Federal ores are in well-defined veins in slate which has been shattered and faulted and pierced by eruptives, the probable source of the metal-bearing fluids which deposited the ore.

Weed estimates the amount of ore blocked out above the tunnel at 90,000 tons and suggests that "this is only a very small percentage of what may be expected from deeper and more extensive mine development." If his expectations are justified the mine is very much larger than the average zinc mine at Joplin.

The northern shaft shows ore of the same kind as that at the Federal shaft, with the slight difference that a little copper pyrites occurs with it, and that there are green stains of malachite. Small quantities of pyrite were found also.

At the time of the writer's visit, August 23-27, 1919, no development work was going on at the mine, the men being employed in grading a road to the mouth of Berry brook, so that transport might be facilitated. It is expected that the 45 miles of road will be put into such shape that motor trucks can carry ore to the railway, thus giving an outlet for the products of the mine. It is also proposed that the 60-foot fall on Ste. Anne river, 10 miles north, shall be utilized for power so as to avoid importing coal as fuel for the hoisting engines, etc.

Another property near by, that of the North America Mining Company, has been prospected slightly and shows ore of a similar kind; it may be expected that other discoveries remain to be made in a region heavily

brush covered and difficult to prospect except along stream beds and mountain tops. The most urgent need at present is improved means of communication.

It is worthy of note that Ells in 1884 suggested that a line of railway from the Canadian National to Gaspé basin over the plateau in the centre of Gaspé would be the shortest and easiest, because of the level character of the country.¹ Such a railway would have passed within a few miles of the zinc deposits just mentioned and would have been of great value in opening them up.

REGION OF LAKE STE. ANNE

The upper part of Ste. Anne river, whose lower waters have already been referred to, is about 5 miles northeast of the Federal Zinc and Lead mine. A day was spent in visiting lake Ste. Anne, and in climbing a mountain to the west of the lake. The region has been briefly described by Mailhiot, who studied it from the point of view of the solid geology and whose party cut out the trail to the river.²

The path descends 325 feet from the Federal camp to a tributary of Berry brook, crosses a narrow watershed to another small tributary stream, and then rises to the main divide between Chaleur bay and the St. Lawrence, at about 1,900 feet. A rapid descent of 2 miles toward the east reaches Ste. Anne river, here flowing nearly north with a moderate current; three-quarters of a mile south the lake opens out.

Scarcely any rock is encountered along the trail, and the lake enters the river very gently in swampy surroundings. Its elevation is given in White's "Altitudes in Canada" as 1,355 feet, on the authority of the Canada Gulf and Terminal railway (Projected extension). The writer's aneroid readings make it 1,357. It is about 5 miles long from southeast to northwest, according to Mailhiot's map, and two narrows almost divide it into three lakes. Its position in comparatively low ground and with no high land between it and the headwaters of Little Cascapedia river to the south, and the fact that it has, according to Low, a greater depth than 120 feet, make its drainage across the highest part of the Shickshocks to the St. Lawrence decidedly puzzling.³ It might be expected to flow into the Little Cascapedia instead of carving a valley 2,500 feet deep between Tabletop and mount Albert.

The mountain just west of lake Ste. Anne was ascended from the highest level on the trail, and proved to be precipitous on its northern side. The upper part of the steep slope is mostly clothed with scrubby spruce very difficult to penetrate, and consists partly of angular rock fragments ending in bare crags. The summit, which is nearly flat and elongated from northwest to southeast, has an elevation of 3,060 feet as determined by aneroid.

The rock is reddish brown, very fine grained, and encloses small porphyritic feldspar crystals. The thin section examined is too badly weathered to give much aid in naming the rock, though it may be placed with the acid eruptives of the region.

¹ Geol. Surv., Can., 1882-4, p. 10 E.

² "Mining Operations in the Province of Quebec", 1917, p. 124, etc., also map at end of report, 1918.

³ Geol. Surv., Can., 1882-4, p. 7 F.

From the summit there is a wide view of the Shickshocks including the Tabletop summits to the northeast, mount Albert to the northwest, and distant members of the range farther west in the Mount Logan region. To the south of the main continuous range there are several isolated peaks like the one climbed. A striking peak rises just across the lake, and two prominent ones rise to the west, Logan's Barnshaped mountain, which Mailhot has happily translated into mount La Grange, and Conical mountain. These isolated mountains appear to be bosses of acid eruptive rocks, probably of the same general age and origin as the Tabletop batholith, but consisting of porphyry rather than granite.

The mountain west of lake Ste. Anne shows no evidence of ice action and probably rose as a nunatak above the glacial sheet which formed boulder clay in the surrounding valleys.



A. Rocher Percé. (Pages 8, 23.)



B. Low tide near ruisseau à la Loutre, ice-borne boulders on shore. (Page 16.)



A. Restigouche valley, sunk in tableland. (Page 26.)



B. Stack of sandstone, village of Tourelle, on terrace (86-113 feet) in background. (Page 17.)

BULLETIN No. 34

PLATE IV



Terraces, Mont-Louis; barley field on lowest (20 feet). (Page 19.)



A. Mont Nicolabert, from forks of Cap-Chat river. (Page 28.)



B. Limestone cliff, cape Gaspe. (Page 21.)



A. On Tabletop. (Page 32.)



B. Summit on southeastern corner of Tabletop. (Page 37.)



A. Causapschal; farms above 1,000 feet on tableland. (Page 26.)



B. Federal Zinc and Lead mine. (Page 41.)

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